

# CERAMICS

APRIL  
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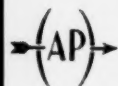


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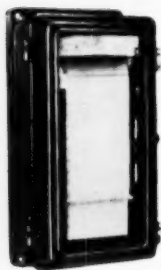
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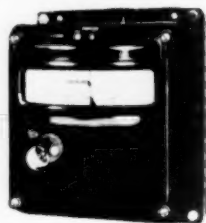
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# CERAMICS

APRIL, 1952

A monthly journal covering  
the whole ceramic field  
including pottery, glass,  
heavy clay, refractory and  
silicate industries.

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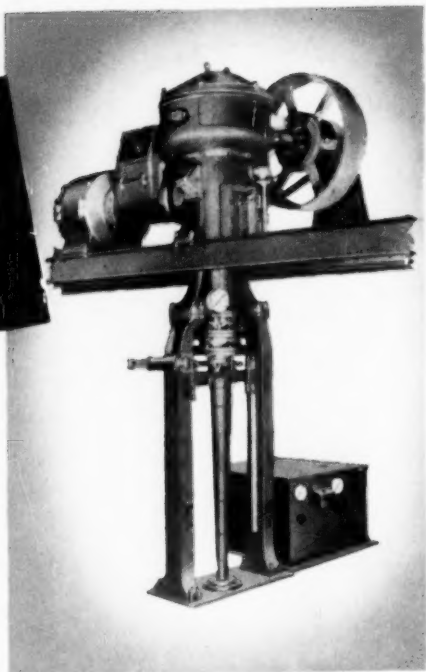
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## REFRACTORIES

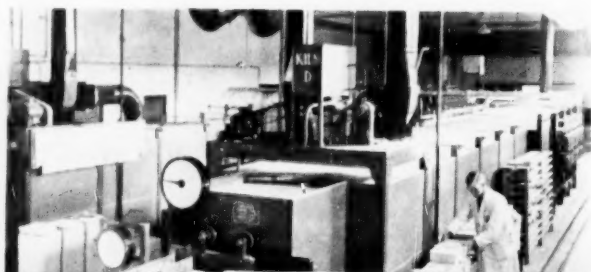
SINCE CERAMICS began as the first British publication devoted entirely to the technical aspects of the clayworking industry it has carried a substantial volume of technical information which has been eagerly sought not only in Britain but in every continent. Whilst every effort was made to balance the editorial content between the different aspects of the industry, it was felt that the pottery industry, the survival of which depends so much upon the application of engineering principles to reduce overall costs, was a worthwhile project. Thus, during the past 18 months there has been the emphasis upon the pottery industry and during this period every stage of the industry has been covered from clay-winning to handling, drying, firing, glazing, decorating, selling, costing, and so on.

However, there is another facet to the ceramic industry which because it is seldom seen tends to be overlooked—namely, refractories. Upon refractories the growth of the steel industry depends, for without them there would be no steel. And it is true to say that every progress stage in the development of better refractories leading to increased performance, reduced costs, better physical qualities, in turn lead directly towards a reduction in the cost of steel, which in turn has its repercussions on the price of the ultimate finished goods. But the usefulness of refractories does not end with the steel industry—the gas industry, coke ovens, producer gas installations, water gas, and so on; all have as their heart, whereby the chemical reactions take place a refractory system. In short, wherever there is combustion there is need for refractories.

And so it is that the editorial balance of CERAMICS has now been adjusted to give the refractory industry a greater and greater coverage in the technological field.

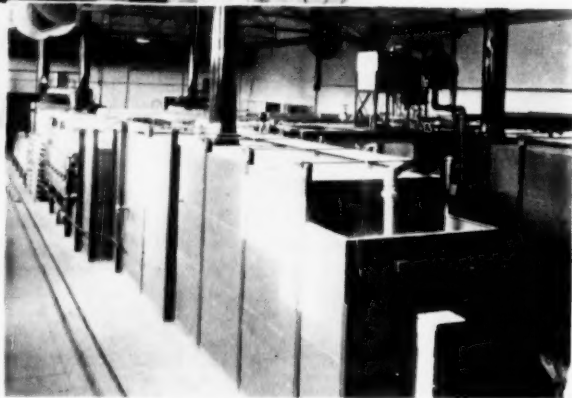
However, in this respect the refractory user has his problems and the editorial pages of CERAMICS are freely available to describe problems which prevail or difficult problems which have been solved. And it is here that the co-operation of the refractory industry, both on the user as well as the supply side, will be very much welcomed.

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# PEOPLE, THINGS and POTTERY

by ARGUS

THE golden days of an expanding British export pottery market have caused much perturbation in America. Firstly there came the grasp of a chunk of the export market by Japan and one cannot but help think that in this respect American support to Japan to regain her pre-war high pottery export market was immense. In spite of repeated requests, it was not possible to guarantee that poor Japanese imitations of British designs and trademarks would not pour on to the American market at a fraction of their production costs in Britain. Then, the German ceramic industry has gradually grown up and there seems little doubt, in Europe at any rate, it will be a severe competitor as indeed it was before the war.

On top of this comes news that Australia, which had been an extremely useful market for pottery exports, is restricting the amount of pottery goods it will import from Britain by 80 per cent.

## Churchill and Pottery

In this respect it is as well to consider the American market. In the *American Ceramic Society Bulletin* for February, 1952, there is an article entitled, **Churchill and the American Pottery Industry**. It reads as follows:

"Winston Churchill, Prime Minister of Great Britain, is one of the worst threats which has faced the American pottery industry in a generation.

"The shrewd English leader, who recently completed a deal with our country for steel in an exchange for aluminium and tin, has a blueprint in his vest pocket that he did not reveal to the American press or his U.S. friends.

"British exports, such as leather goods, textiles, Scotch whiskey, insurance, carrying charges on our world shipments, or tourists-in-England in-

come, are not adequate enough to righten a sagging British budget.

"Though Mr. Churchill does not specifically say so, he does indicate that Britain's exportable surplus must rise.

"What, then, can our overseas friends export that will find a ready American market and help offset the erosion in the British Budget?

"One of the easiest products to sell in the American market is British pottery. British supplies of raw material are good, designs are well accepted, and the American public is, unfortunately, receptive."

## Pottery Imports

"For many years the British have probed and exploited the American pottery market with good results. Cleverly, they have promoted the idea that it is good because it is imported.

"Although this idea was earlier rejected by the American public on agricultural machinery and later was completely disproved in French automobiles, it has been made to stick on dinner ware and certainly textiles.

"This stereotype buying hasn't spread to the radio and television industry, but housewives, with more than 85 per cent. of the nation's spending pocket book, seem to be fully hypnotised by the charm of the trademarks of English potters on the undersides of British plates.

"They even buy expensive books that list these marks for ages back and that describe the factories where they are made.

"So, Mr. Churchill blandly accepts this 'point of purchase' situation in his benign manner and uses it to help balance the crumbling British Budget.

"Socialism in Britain may be distasteful to many Americans, and Mr. Attlee may not have been the American business man's choice for the

## CERAMICS

British Premier, but if the Conservative Party in Britain can make good on its promises, English ships will be carrying much more than aluminium from Canada and tin from Malaya to our ports.

*"They will be carrying pottery from Britain to American tables."*

Recently the Conservative party leader assured his associates that he could re-establish Britain's economic stability.

Mr. Churchill, while he is 11 years older than his World War II Prime Minister days, while his voice lacks the acoustical 'thump' of yesterday, and while his French is improving, is nevertheless 11 years more crafty. This classifies him in keeping with the typical British tradition—a good diplomat and a good salesman.

### Salesman De-luxe

Prime Minister Churchill, British pottery salesman de-luxe, will be the toughest competitor the American pottery industry has met in many a year.

Thus, since this bulletin is officially published by the American Ceramic Society, one cannot help but feel that there is behind it a move to restrict, as far as possible, supplies of British pottery in America.

This article should be read by Mr. Gordon Russell of the Council of Industrial Design when he comments upon the desirability of the British pottery industry changing to contemporary designs. The article quoted above shows quite clearly that the American market has been broken into, to an extent which worries even the American potters. Nevertheless, as the American pottery industry has been taking a knock for some time, and since the war has at times been reduced to working for three days a week, it is not unlikely that the American industry will seek protection for itself.

### Quality Price Ratio

More and more this industry is being driven to consider the quality-price ratio. Although in the words of the writer in the *American Ceramic Society Bulletin*, "American housewives seem to be hypnotised by the charm of the trade-marks of English potters on the under-sides of British plates," nevertheless, restricted sup-

plies of free money for the purchase of consumer goods which is now being experienced in America, Britain and elsewhere, will undoubtedly react to a stage where the buyers become "hypnotised by the price on the under-sides of British plates." The pottery industry has been attacked by forces outside its control during the past year or so. In the first place it involved capital expenditure in the installation of expensive tunnel kilns using Town's gas or electricity as a heating medium. Within the past 12 months it has faced very high tariff increases on the cost of its fuel.

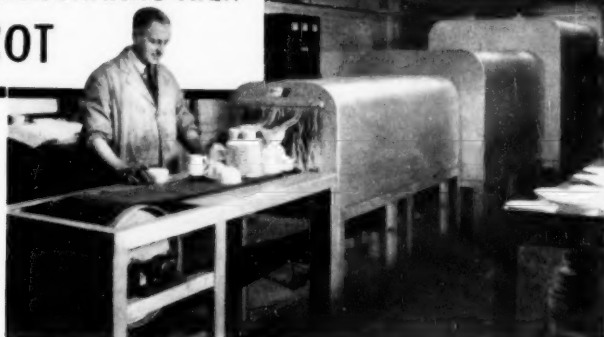
Even prior to the recently published budget the industry was facing a request for increased wage rates. Undoubtedly the rising prices, which cannot be stemmed by manipulation of the national profit and loss account, will result in these demands being pushed forward most vigorously.

### In All Directions

Thus, as far as this closely knit and geographically insular industry is concerned, it is feeling the squeeze in all directions. Outside influences are reacting upon that vital price quality ratio at a time when there is, simultaneously, a curtailment of pottery imports into many markets and a definite hardening of the American pottery industry towards the import of British goods. Admittedly it is in a cleft stick, but the existence of the industry in a prosperous state does not end and begin with Stoke-on-Trent. The suppliers to the industry of materials and equipment come from far away. The workers in the pottery industry, however, feel the pinch very much at home. If this increase in cost of British pottery does continue to spiral upwards, it is crystal clear that unemployment will once again mar the pottery landscape, as once did the smoke some 25 years ago. Surely there was never a time when both manufacturers' and workers' organisations should get together with a spirit of compromise—it is only compromise which can prevail in these circumstances and the short answer is that maybe a temporary loss suffered now in terms of profits, wages and salaries, might avoid a total wreck.

Yet it is vitally important to the industry and to those concerned with

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their livelihood upon that industry, that the writing on the wall is read clearly for, indeed, it will serve little purpose to say later, in any branch of the industry, that "I did not know!"

#### University Economists

From time to time in this column criticism has been made of the adverse effect of university graduates upon the organisation of industry. Recently, Mr. W. G. South came over from Sydney, Australia, and had some pertinent things to say about the effect of university economists in particular. He commented to the *Evening Sentinel* as follows:

"You have a London University and I suppose, other universities, turning out Professors of Economics by the gross, and it is generally admitted that the bulk of these professors are really very narrow in their views.

"To conduct a business successfully in Australia or England, a man has to have imagination. That is absolutely absent in Professors of Economics. Your universities, having supplied the requirements of England in Professors

of Economics, are sending the overflow out to Australia, and we have a perfect blight of them there.

"They are relied upon too much by the politicians, who take their advice which is often narrow, misleading and crude."

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# CRYSTAL GLAZES

(SPECIALLY CONTRIBUTED)

CRYSTALLINE glazes have been produced fortuitously for a long time, but it is only in comparatively recent times that the phenomenon has been studied scientifically. According to W. H. Zimmer (*Trans. Amer. Ceram. Soc.* 4, 38, 1902) Ebelman studied crystalline glazes in 1847-52, but C. Lauth and G. Dutailly produced a paper on the subject and a cup for the National Factory at Sevres on 19th September, 1885. Their glazes were based on the crystallisation of zinc silicate. G. Vogt states that the first crystallisation glazes were made at Sevres in 1884.

## Types of Crystalline Glazes

In dealing with crystal glazes one has to consider the following:

1. The type prized by the collector, in which very decorative effects are produced by the growth of crystals, often against a contrasting coloured background, in a glaze.

2. The unwanted crystals which sometimes appear as a result of incorrect firing of ordinary glazes.

3. The peculiar and decorative effect known as the rutile "break up" which is very popular for tile hearths and surrounds.

4. The very fine crystals which produce matte and vellum surfaces on glazes.

5. The crystallisation which is responsible for the opacity in self-opacity frits used for some types of vitreous enamels.

The first type formerly occupied a greater space in the technical literature than it does today. Very beautiful examples of the potter's art can still be made, but the difficulties of inducing crystallisation in a super-cooled glassy medium such as a glaze, are so great that the results cannot be repeated with certainty in successive firings. Moreover, modern firing conditions, with rapid cooling cycles, do not favour the production of crystals. It is not surprising, therefore, that

these glazes are no longer of commercial significance, and that their production is left principally to enthusiastic amateurs and studio potters.

Commercially, vellum and matte glazes, and certain types of tiled articles, are the only types to be considered. The former are obtained by creating the conditions in which small crystals of calcium and zinc silicates can form, and the coarser the crystals the more matte the surface. Rutile break-ups are obtained by the crystallisation of rutile in the glaze, and again the size of the crystals conditions the effect produced.

## Starring and Feathering

This is a fault that is familiar to most potters. The name is used somewhat indiscriminately to describe the appearance of long crystals on the surface of glazed ware. Where the kiln has been deliberately held back to allow some part to rise in temperature, the conditions in the portion held back may favour the crystallisation of the glaze. This results in "aired" ware. Where sulphur gases are present in the kiln sulphates may be formed by the interaction of these gases with the glaze. When this happens in the later stages of firing the sulphates do not dissolve in the glaze, but remain on the surface as crystals, giving what is known as "sulphured" ware. Good ventilation of the kiln is recommended where this is likely to occur.

## Conditions for Crystallisations

The optimum conditions for crystallisation of glazes involve:

- (a) the composition of the glaze
- (b) the firing cycle.

There are many formulae for crystalline glazes quoted in the literature, with optimum firing temperatures given, and many are the enthusiasts who have made up these glazes and been disappointed to find, after firing, only brightly glazed pieces in the kiln. The reason is undoubtedly that the firing

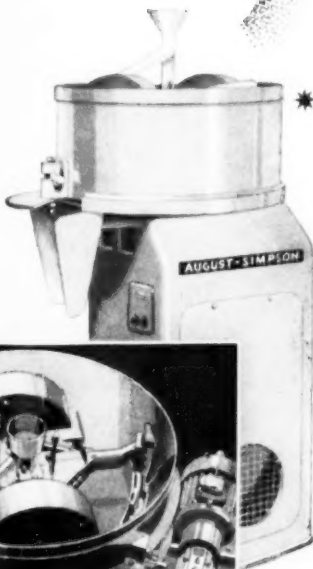
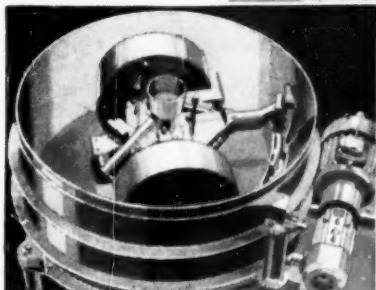
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conditions, and particularly the rate of cooling have been unsuitable.

#### Effect of the Rate of Cooling

The late Dr. W. J. Mellor (*Trans. Brit. Ceram. Soc.* 5, 75, 1905-6) showed that for most glazes the rate at which crystals could form was highest in the temperature range 750-850° C. Rapid cooling through this zone results either in failure to obtain crystals, or the production of poor specimens. Other workers have concluded that the rate of cooling is important, and have studied this at different rates with particular glazes. Thus H. Thiemecke (*J. Amer. Ceram. Soc.* 17, 359, 1934) studied the effect of cooling a raw glaze, maturing at Cone 10, of the following molecular formula:

|                       |   |                                     |                      |
|-----------------------|---|-------------------------------------|----------------------|
| 0.16 K <sub>2</sub> O | { | 0.24 Al <sub>2</sub> O <sub>3</sub> | 2.2 SiO <sub>2</sub> |
| 0.43 MgO              |   |                                     |                      |
| 0.31 CaO              |   |                                     |                      |
| 0.08 ZnO              |   |                                     |                      |
| 0.02 BaO              |   |                                     |                      |

made from the following mixture: Felspar 35 per cent., whiting 12.5 per cent., zinc oxide 2.5 per cent., barium carbonate 14.5 per cent., ball clay 3.5 per cent., flint 25.5 per cent. It was found that the cooling rate affected the size of the crystals, or even whether they developed at all. Generally speaking a cooling rate of 100° C. per hour gave the best results, faster rates gave matte effects with interlocking crystals, and slower ones reduced the size of the crystals, and finally at 400° C. per hour no crystals were formed. For further details, and for the effect of colouring materials added to the glaze, the original paper should be consulted. It also gives a good bibliography on crystalline glazes.

F. H. Riddle (*Trans. Amer. Ceram. Soc.* 8, 236, 1906) carried out experiments with zinc silicate crystalline glazes. The following frit was made, ground, and doped with dextrine before application:



|              |                 |
|--------------|-----------------|
| Zinc oxide   | 27.39 per cent. |
| Pot. nitrate | 7.38 per cent.  |
| Borax        | 13.77 per cent. |
| Whiting      | 7.20 per cent.  |
| Boric acid   | 4.47 per cent.  |
| Copper oxide | 0.60 per cent.  |
| Flint        | 39.69 per cent. |

This glaze was heated fast to Cone 02 down, and soaked at that temperature for 1 hour. It was rapidly cooled to Cone 010 (approx. 890° C.) and held there for 4 hours, after which cooling was resumed slowly. It will be recalled that in an earlier section it was pointed out that there is a temperature range within which the rate of crystallisation of the glaze is at a maximum. The value quoted is very near that given by J. W. Mellor (loc. cit.) for the glazes which he studied. Other examples might be quoted from the literature to prove the importance of the cooling rate on the growth of crystals in glazes, and it is unfortunate that in many of the older recipes for crystalline glazes no details were given of this.

#### Effect of Composition

It is a well-known fact that the glaze composition has a considerable effect upon the likelihood of crystal-

lisation in a glaze. Alumina is deliberately added to bright glazes to prevent it, and conversely it is either omitted altogether, or considerably reduced in crystalline glazes. Since zinc silicate forms well-defined crystals these glazes are usually high in ZnO, and often a little rutile is added to afford nuclei on which the crystals can grow. F. H. Norton (*Trans. Amer. Ceram. Soc.*, 20, 217, 1937) has demonstrated the importance of this. High alkali, alumina, and silica are unfavourable to crystal growth.

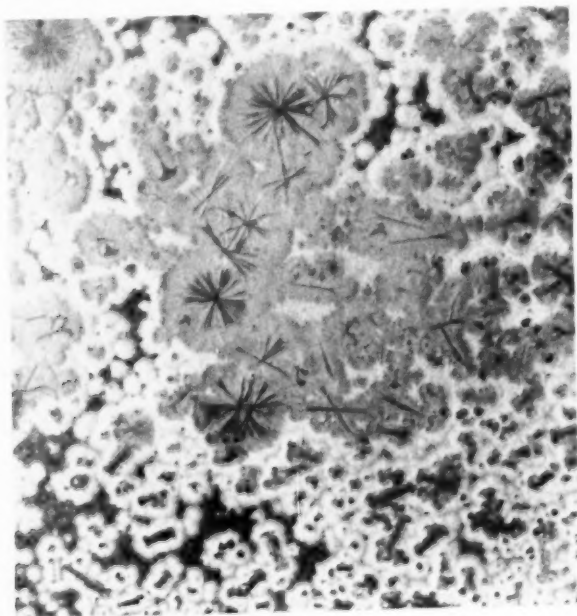
#### Blue Zinc-Nickel Crystal Glaze

These points are illustrated in an in-glaze zinc-nickel blue crystalline glaze of Dr. Barsch, described by J. W. Mellor and H. Wicks (*Trans. Brit. Ceram. Soc.*, 13, 62, 1913-14). The formula for this glaze is given as:

|           |                        |                                     |
|-----------|------------------------|-------------------------------------|
| 0.063 NaO | 0.038 AlO <sub>3</sub> | 0.867 SiO <sub>2</sub>              |
| 0.086 KO  |                        | 0.038 TiO <sub>2</sub>              |
| 0.110 CaO |                        | 0.188 B <sub>2</sub> O <sub>3</sub> |
| 0.063 BaO |                        |                                     |
| 0.617 ZnO |                        |                                     |
| 0.013 NiO |                        |                                     |

This was fired to Cone 9 in a china biscuit oven, and the recipe is given for those who may wish to try it. It often gives good results:

Typical  
crystal  
glaze



| Frit           |     | Raw        |    | Mill         |    |
|----------------|-----|------------|----|--------------|----|
| Pearl ash      | 69  | Felspar    | 28 | Frit         | 70 |
| Whiting        | 50  | Whiting    | 35 | Raw          | 30 |
| Barium carb.   | 99  | Flint      | 54 | Rutile       | 3  |
| Borax crystals | 191 | China clay | 36 | Zinc oxide   | 50 |
| Boric acid     | 62  |            |    | Nickel oxide | 1  |
| Flint          | 270 |            |    |              |    |

Pieces are dipped in this glaze and fired to Seger Cone 9 (approx. 1,250°C). Good results have been obtained by placing the ware in the third ring of a china biscuit intermittent oven about six saggars down. In this position the rate of cooling is slow. This glaze gives electric blue needles against a yellow background, and the effect is very pretty. Mellor and Wicks recommend other colouring agents which can replace the nickel oxide to give crystals in other colours; in particular ferric, manganese and cobalt oxides.

A disadvantage of glazes high in zinc oxide is the high maturing temperatures. There are other recipes quoted in the literature to mature at lower temperatures, but the effects are often not as certain as the glaze given above, and in some cases the crystals do not show against different coloured background.

#### Crystallisation by Overloading the Glaze

When a substance is more soluble in a glaze at higher temperatures than at lower ones, it is possible to overload it, and let the excess separate on cooling. If the excess appears as crystals the effect can be decorative, if not a scum appears on the surface of the glaze. Thus when an ordinary glaze is overloaded with copper oxide and allowed to cool the excess sometimes separates as a matte surface in which appear metallic-like crystals. The effect is not unpleasing, and has been used for inserts in tiled hearth surrounds, although the surface is not as durable as some other types. Overloading a lead glaze with manganese dioxide often produces an opaque metallic-looking glaze on cooling, which is popular for some kinds of tea pots.

#### Aventurine Glazes

With other substances it is possible to produce beautiful crystalline spangles in the glaze, and that with

iron oxide resembles the mineral aventurine, so that glazes of this type are often called aventurine glazes. They appear first to have been studied by Machler in 1896. Since the glaze merely acts as the solvent for the material which is to crystallise, it is unnecessary to have crystallising agents such as zinc oxide and rutile in the glaze, but it is advisable to use a glaze which will dissolve the maximum amount of the material at the maturing temperature. The most popular aventurine glaze is made by dissolving ferric oxide in a highly alkaline glaze. This develops a rich reddish-brown glaze, in which the excess iron oxide separates as golden spangles. Like all crystalline glazes the result is somewhat capricious, and goes better on red or buff bodies, possibly because these contain specks of iron oxide which act as nuclei on which the crystals form. An example of an aventurine glaze is the following:

|                                |      |   |                                    |   |                                    |
|--------------------------------|------|---|------------------------------------|---|------------------------------------|
| Na <sub>2</sub> O              | 0.4  | } | 0.01Al <sub>2</sub> O <sub>3</sub> | } | 3.53 SiO <sub>2</sub>              |
| K <sub>2</sub> O               | 0.1  |   |                                    |   | 0.81 B <sub>2</sub> O <sub>3</sub> |
| BaO                            | 0.07 |   |                                    |   |                                    |
| Fe <sub>2</sub> O <sub>3</sub> | 0.43 |   |                                    |   |                                    |

This is prepared by fritting completely:

|                     |     |
|---------------------|-----|
| Flint               | 444 |
| Borax crystals      | 330 |
| Iron oxide (ferric) | 148 |
| Felspar             | 14  |
| Nitre               | 38  |
| Barium carb.        | 27  |

The frit is ground, and if difficult to apply, it may require doping with 1 per cent. bentonite, followed by sufficient drops of a saturated solution of calcium chloride to thicken the glaze sufficiently. The pieces should be stood on a thick layer of bitstone, as the glaze runs badly.

It may be necessary to grind off the bitstone from the bottom of the fired pieces.

Machler's glaze is prepared by fritting the following:



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|            |    |
|------------|----|
| Pearl ash  | 10 |
| Borax      | 28 |
| Whiting    | 14 |
| Flint      | 39 |
| Boric acid | 9  |

This gives a molecular formula of:

|                        |                                    |
|------------------------|------------------------------------|
| 0.25 K <sub>2</sub> O  | 2.25 SiO <sub>2</sub>              |
| 0.25 Na <sub>2</sub> O |                                    |
| 0.5 CaO                | 0.75 B <sub>2</sub> O <sub>3</sub> |

To this is added 25 per cent. of ferric oxide or its equivalent. The metal itself is said to give the best result, then ferrous carbonate, and finally ferric oxide, in that order.

C. W. Parmelee and J. S. Lathrop (*J. Amer. Ceram. Soc.* 7, 567, 1924) have drawn the following conclusions on the production of iron aventurine glazes:

- (a) The beneficial effect upon crystallisation of the RO members of the glaze is in order 1, soda; 2, potash; 3, lead; and 4, lime. Consequently the latter should be kept at a minimum,

and increasing soda at the expense of the lead is an improvement.

- (b) Medium thick application of glaze (<2mm.) is best.  
 (c) Increasing iron content increases the size and the number of the crystals, and also the refractoriness of the glass.  
 (d) Increasing alumina retards development of the crystals.  
 (e) The best effect was obtained with the glaze:

|                   |                                     |                                    |
|-------------------|-------------------------------------|------------------------------------|
| Na <sub>2</sub> O | 0.15 Al <sub>2</sub> O <sub>3</sub> | 7.0 SiO <sub>2</sub>               |
|                   | 0.75 Fe <sub>2</sub> O <sub>3</sub> | 1.25 B <sub>2</sub> O <sub>3</sub> |

This matured at Cone 1.

#### Other Types of Aventurine Glazes

Other substances can be used for producing aventurine glazes, e.g., copper chromate. C. F. Binns' "Manual of Practical Potting," London, 1922, gives the following formulae for glazes maturing at about 985° C.:

# CERAMICS

| GLAZE 1  |       |  | GLAZE 2    |     |               |    |
|--|-------|--|------------|-----|---------------|----|
| Frit   |       |  | Frit       |     | Mill          |    |
| Borax  | 30.0  |  | Borax      | 100 | Frit          | 70 |
| Flint  | 35.0  |  | Flint      | 35  | Stone         | 5  |
| Stone  | 5.5   |  | Whiting    | 8   | Iron oxide    | 6  |
| Nitre  | 2.5   |  | White lead | 15  | Iron chromate | 4  |
| Iron oxide   | 6.0   |  |            |     | Copper oxide  | 4  |
| Copper oxide   | 0.25  |  |            |     |               |    |
| Barium chromate                                      | 0.125 |  |            |     |               |    |
| The frit is ground and applied to the ware and fired |       |  |            |     |               |    |

Uranium oxide can also be used to produce an aventurine effect (cf., J. R. Lorch, *J. Amer. Ceram. Soc.* **10**, 813, 1927).

## Matte Glazes

In these the glaze is made to crystallise, and is often rough in texture so that it can be marked with a pencil, or with soft metal. Crystallisation is usually induced by the addition of lime or zinc oxide to the glaze, and the crystals are of wollastonite  $\text{CaO} \cdot \text{SiO}_2$ , or willemite  $\text{ZnO} \cdot \text{SiO}_2$ . This affords a classification of matte glazes into the "lime mattes," and the "zinc mattes." As with all true crystalline glazes, rapid cooling may prevent the development of the matte surface.

## The Zinc Mattes

These are produced by the addition of zinc oxide to an ordinary glaze to the extent of 30-40 parts by weight to 100 of the glaze. The crystals obtained are often rather big, and the surface too rough. To get over this difficulty the matting agent is usually a mixture of zinc oxide and china clay, mixed in equal amounts and calcined before use. This is used in place of the zinc oxide. The alumina from the china clay reduces the size of the crystals, with an improvement in the surface. These glazes have a tendency to crawl, and the purpose of the calcination is to destroy the plasticity of the china clay, which might otherwise lead to the formation of cracks in the surface of the glaze on drying, with the risk of crawling in the subsequent firing.

## Satin Vellum Glazes

In these glazes the crystal structure is very much finer than in the matte glazes, and the surface is much

smoother. They are simply prepared by the addition of approximately five parts each of zinc oxide, titania, and tin oxide to 100 parts of an ordinary bright glaze, and firing to tile glost temperature. Satin vellum surfaces have a much more pleasant texture than the dead matte surfaces, and are very popular at present for tiles, and certain types of ware.

## Lime Matte Glazes

These are made in the same way as the zinc matte glazes, except that lime is added to the ordinary glaze in place of zinc oxide. The resulting surface is dull, and easily marked, and not very resistant to the effects of acids or of weathering. This is one of the reasons why matte glazes are not as popular nowadays as the vellum and satin-vellum types.

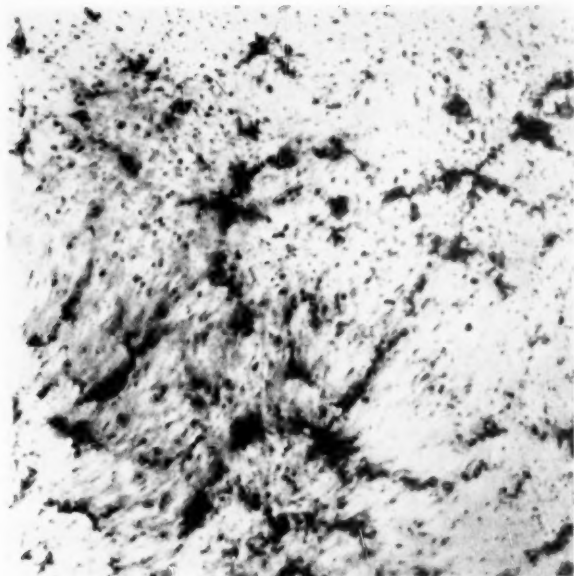
## Rutile Glazes

When about 8-9 per cent. of rutile is added to a glaze, then on cooling some of the titania crystallises, and in addition, the crystals are usually surrounded with yellow and brown patches, due to reactions with the glaze components to form coloured titanates, usually of lead and zinc. These give the "rutile break-up," and the effect is very popular for tiled hearth surrounds. The break-up is most pronounced with pulverised rutile. Finer grinding, as with water-ground material, leads to a finer and more regular pattern. If over-fired the crystalline patches dissolve in the glaze, and the result is a cream-coloured matte glaze.

## Self-opacifying Frits

Titania is also a component of the self-opacifying frits used by the vitreous enameller. These are colourless, or straw coloured, and transparent

Typical  
vulnity  
"break-up"  
on  
tile



when made, but on re-firing they become opaque due to crystallisation. There are two types: (a) the "zinc titanate" type, which are not acid-resisting, and which contain 18-20 per cent. titania, and up to 20 per cent. or more of zinc oxide, and (b) a type which is now more important, and which has 18-20 per cent. titania, with low alkalis and relatively high silica content. This is the acid-resisting type. Typical formulae are (cf., "Vitreo-Enamels," Borax Consolidated Ltd., London, 1949),

|                | Zinc Titanate type | Acid Resisting type |
|----------------|--------------------|---------------------|
| Borax          | 24.5               | —                   |
| Felspar        | 4.5                | —                   |
| Quartz         | 25.3               | 50.2                |
| Soda ash       | 24.2               | —                   |
| Soda nitrate   | 2.4                | —                   |
| Pot. nitrate   | —                  | 9.7                 |
| Titania        | 17.2               | 17.25               |
| Zinc oxide     | 19.5               | 1.0                 |
| Limestone      | 3.4                | —                   |
| Cryolite       | 2.6                | 3.3                 |
| Boric acid     | —                  | 4.6                 |
| Mag. carbonate | —                  | 2.1                 |
| Pot. phosphate | —                  | 1.45                |

These frits are an important

development in vitreous enamels, as they can be used to finish certain classes of ware with one cover coat only.

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# PRESIDENTIAL ADDRESS

by

D. SALT

MY first duty, as your President, is to pay public tribute to my predecessor in office, Mr. Hulse. I am sure that it will be your wish that I record the Association's appreciation of his services, and I do ask him on your behalf, and on my own, to accept our most sincere thanks for the conscientious and dignified manner in which he has carried out his duties.

For my own part, I must now thank you all for the kindness and the honour which you do me in asking me to become your president. As this present, eventful, day has approached, I have searched for some suitable motto which I could adopt for my year of office. Turning back the pages of history I found *Rosa sine spino* (which I presume means "Rose without a thorn"). Modesty alone forbids its use. Then I found *semper eadem* ("always the same"), quite obviously no self-respecting pottery manager could possibly use this, and so on, until, having examined the mottoes and the battle-cries of history, I found again *Ih dien* ("I serve"). This indeed, will I try to do, and to carry out, in all things, your wishes, and to endeavour at all times, to be a credit to you and to this virile Association.

As we stand on the threshold of our own Association year, I think that it would be well to give public voice to our opinions on the various matters which confront the industry in these difficult days.

## Not A Trade Union

Firstly, then, let us make it clear beyond the slightest shadow of doubt that this Association is in no way a Trade Union.

The Trades Union movement has an important and honourable part to

play in the economic life of this country, and, given wise and sober leadership, can make substantial contributions to our industrial stability, and, consequently, to our national prestige throughout the world.

Much as we appreciate the importance of the Trades Unions, however, we desire most emphatically to state that the British Pottery Managers' and Officials' Association is something not merely wider or higher than Trades Unions, but something which, in its conception, in its life, and in its aims, possesses an entirely different nature.

Since its inception, in 1918, the Association has encouraged and promoted the advancement of pottery management in all its aspects, by the interchange of technical, economic, and practical knowledge between its members, and by fostering the type of membership which realises that it will receive from life just as much—and only as much—as is put into it in terms of real work and effort.

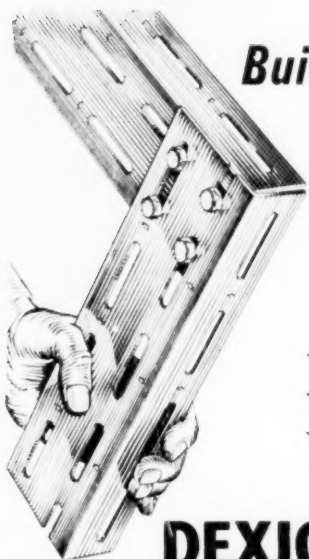
Members joining the Association should ask themselves not "what can I get out of it?" but "what can I put into it—into the Association—into my job—into the industry?"

During the past few weeks, there have been two important events destined to have far-reaching effects on our industry, and on our lives—(i) the reduction in Australia's imports, and (ii) the Budget.

Both facts in themselves are unrelated; individually, or together, they constitute a challenge which will test us to the uttermost, and may well decide for a decade, our individual and collective prosperity.

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## CERAMICS

moon was over, and that the transition from a sellers' to a buyers' market was complete—and was indeed, giving place to a further state of severe world competition, and hard comparisons of quality and prices.

Australia's action has at last brought our British people certainly our potteries' people face to face with the hard facts that our business and our livelihood, our interests, and our industry, are entirely dependent on world conditions.

There has been much glib talk about quality—and far too much complacent assurance that British pottery is the best in the world—it can be—it should be—it most assuredly will not be, if managers and operatives alike do not realise that the Americans and the Continentals (of Denmark, of Germany, and of France) are capable of producing work of exquisite quality, such quality as only our finest efforts can beat.

Let us not try to live on the reputations of the past, let us fight to see that British pottery of our present day—and not of a bygone age—holds its premier place in the world.

More serious still is our question of price. Let there be no doubt in anyone's mind that our goods must be made cheaper in price if our future is to be at all secure.

Let no one be deluded into thinking that we in this country are above price-comparisons with our competitors. We are not.

Output per person must be stepped up, and both indifference, and the "couldn't care less" attitude, must give way to the pride of the craftsman who is content only when giving of his best.

Time-keeping and break-times should become handmaids to production, and not act as brakes upon it.

Every mechanical device which can

be used—every applicable tool of science—every conceivable aspect of human understanding—must be brought into play, to increase our productivity, and reduce selling prices.

Let manager and operative alike realise that unless this is done—quickly, and wholeheartedly—then we shall not be in a position to survive the further shocks which lie ahead.

## The Budget

All too often, a Budget is judged as good or bad according to the amount which it puts into, or takes out of, one's own pocket. Most Budgets in this sense are bad.

In the wider, and more rational sense, a Budget is good or bad in so far as it brings prosperity to the community.

A country is as wealthy as its productive capacity. There is no secret in the fact that the productive capacity of this country has been strangled, in recent years—almost choked out of existence—by the penal rate of taxation.

As managers we know how often a piece-worker has been inclined to go a little slower—how often a day-wage person has refused overtime—simply because the tax made it not worthwhile? The production machine has been driven with brakes on.

The new rates of tax restore incentive to increase production, and to work harder, or longer, if necessary.

By increased productivity alone can the nation—and with it, our own industry survive. As an incentive to this end, the recent Budget may well prove to be a turning point towards national solvency.

As then, we face the difficulties ahead, let us declare with emphasis our belief that we, as an Association, will play our part, and that we shall not be found wanting.

## LABELS FOR GAS CASUALTIES

THE works safety committee of the Association of British Chemical Manufacturers, 156 Piccadilly, London, W.1, has given consideration for some time to the important question of correctly labelling casualties sent to hospitals so that the correct history and diagnosis of the cases is given. A panel consisting mainly of industrial medical

officers has investigated this problem and evolved a series of labels which are now available for factories likely to experience gas casualties.

Copies of a booklet describing the scheme and showing representative labels are available from the Association, price 3s., post free. From the same source labels may be purchased in bulk.



# LITHIUM CERAMICS

RECENTLY\* there has been announced a range of ceramic materials which are claimed to have a very good thermal shock resistance, and are based upon lithium aluminosilicate. Another quality is a low coefficient of expansion so that it is possible to make components which will hold their dimensions over a wide temperature range and the composition can be varied to provide a range of coefficients of thermal expansion on

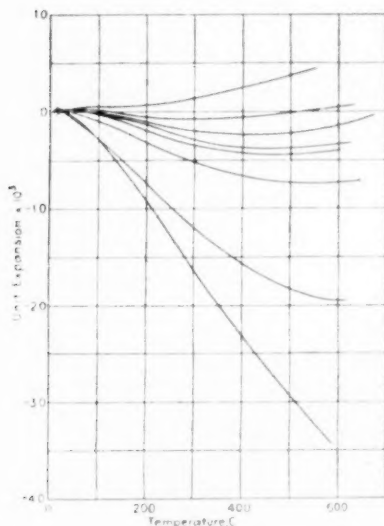


Fig. 1. Thermal expansion curves of various Stupaleth compositions

both the positive and negative sides.

Clay, or mixtures of other ceramic materials, are blended with lithium-bearing ores to maintain the ratio lithium:alumina:silica, in the desired proportion. In effect there is an upper limit to the proportion of silica because at this stage there is a phase change of the free silica when it is heated or cooled through a critical temperature so that it loses its thermal shock resistance. On the lower end

of the scale, if the silica falls below a certain minimum, a negative coefficient of expansion is obtained so that the material actually contracts when heated. For example, a composition on the silica side with a thermal coefficient of expansion of  $2 \times 10^{-6}$  in./in./°C. in the temperature range 70-950° F. is obtainable whilst on the other extreme, compositions with a coefficient of thermal expansion of  $-6.25 \times 10^{-6}$  in./in./°C. are possible.

Out of these compositions emerge two groups, the first with low thermal expansion and which are referred to as "zero" compositions. Next comes the non-porous range with low water absorption, low thermal expansion, and good electrical properties. In the first group the coefficients of linear expansion range from  $0.063 \times 10^{-6}$  in./in./°C. to  $-0.063 \times 10^{-6}$  in./in./°C., whilst the second group have coefficients of linear expansion of  $0.8 \times 10^{-6}$  in./in./°C. in a temperature range of 70-950° F.

## Test Results

From what has taken place it appears that the materials are quite suitable at high temperatures—tests have been carried out at 2,000° F. for 30, 60, 90, and 120 days without any apparent change. Their chemical stability is good below 1,800° F. but tend to react with some materials at higher temperatures. The shock resistance has been shown by heating laboratory specimens to 2,000° F. and dropping into liquid air 100 times. In forming components, extruding, casting, ramming and pressing methods are employed. It is possible to manufacture to very close limits whilst parts can be both machined or ground after the firing stage. It is claimed in America that the ceramic components containing lithium are comparable in price with similar parts made from fine china, from vitreous china, or steatite.

Among applications of the material are included kiln furniture, high-temperature jigs, components for induction heating formers for high-temperature coils, whilst they are being

\* *Materials and Methods*, 35/1, 1962, pp. 98-99.  
"New Lithium Ceramics"—R. E. Stark and R. H. Dilks, Stupakoff Ceramic Manufacturing Co.

# CERAMICS

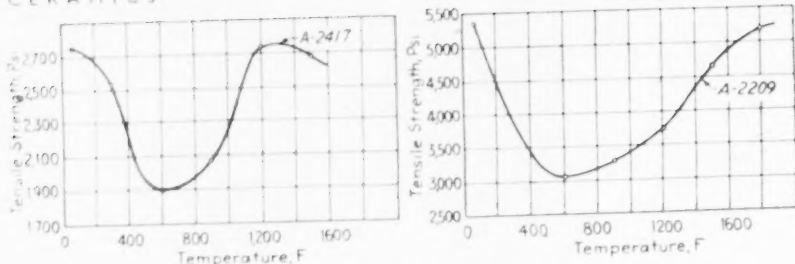


Fig. 2. Tensile strength vs. temperature for two of the new lithium ceramic compositions

investigated for flame-resistant cooking ware and thermocouple protection tubes.

The property of "zero" thermal expansion makes them available for jet engine parts, turbine plates, and nozzle inserts, whilst the controlled thermal expansion property offers scope as thermostat core rods and furnace liners. The chemical resistance at

high temperatures makes them applicable for use as combustion tubes in laboratory pickling tanks and ladles for pouring metals. Table 1 shows the properties of these lithium ceramics, while Figs. 1 and 2 show thermal expansion curves of different compositions and the tensile strength at various temperatures for two compositions.

TABLE 1. PROPERTIES OF LITHIUM CERAMICS

|  | Typical "Zero" Expansion Body | Typical Non-porous Body |
|--|-------------------------------|-------------------------|
| Compressive strength, p.s.i.                             | 19,880                        | 69,800                  |
| Impact strength, ft.-lb./sq. in.                         | 0.90                          | 1.40                    |
| Modulus of rupture, p.s.i.                               | 4,250                         | 8,000                   |
| Moisture absorption, per cent.                           | 21.5                          | 0.00                    |
| Bulk density, gm./cc.                                    | 1.60                          | 2.34                    |
| Coefficient of thermal expansion, 20-500°C., in./in./°C. | $0.063 \times 10^{-6}$        | $0.85 \times 10^{-6}$   |
| Thermal shock, 2,300°F. to cold water                    | 900                           | 900                     |
| Power factor, per cent.                                  |                               | Wet Dry                 |
| Dielectric constant                                      | 9.00                          | 0.492 0.424             |
| Loss factor, per cent.                                   |                               | 5.56 5.57               |
| Dielectric strength, volts mil.                          |                               | 0.0273 0.0236           |
| IAN Spec. 1-10 I. Grade                                  |                               | 450.0 450.0             |

## CORRESPONDENCE

### FAMOUS PORCELAIN FROM EASTERN EUROPE

In the March issue our Correspondent, writing on the Herend factory, said, "... of course, nobody knows what happens today at Herend, under Communist management ...". Dr. Flodora Sos writes to say things are still all right! Editor.

SIR.—Despite your correspondent's pessimism, expressed in the article "Famous Porcelain from Eastern Europe," the Herend porcelain factory is doing remarkably well these days.

Since nationalisation the best Herend traditions have been encouraged, and Herend china is widely sold both in Hungary and abroad.

On page 44 of the enclosed copy of Hungarian Foreign Trade you will find an article describing the present activities of the factory.

Yours very truly,

Dr. FLODORA SOS,  
Director, Hungarian News and Information Service.

# PAINTING BRICKWORK AND STONEMASONRY

**T**HERE are, of course, a number of different reasons why brickwork itself should be painted—it may be for hygiene, or appearance, water proofing, improving the reflection of light or reducing the amount of heat absorbed from the sun. In any case the painting of new brickwork does present a number of problems largely due to the presence of moisture as well as the alkaline nature of the mortar used and the efflorescence of the same mortar.

## Exterior Painting

In the case of exterior painting those paints which are recommended are oil gloss linseed oil paints, full gloss paints, alkyd resin paints or full gloss enamels, covered by British Standard Specification 261.

Where it is essential to prevent rain penetrating the brickwork, oil-bound water paint is not advisable. The oil gloss and full gloss paints mentioned above are quite durable and as long as the film is not cracked it will exclude rain. However, a gloss paint on brickwork often does not look very attractive and in such cases it is often advisable to use an imitation stone paint which incorporates a drying oil or an emulsion having some degree of resistance to alkali.

Cement paints, which are really white or coloured Portland cement, formulated to be mixed with water to form a paint, give a smooth matt finish and a high degree of water-proofing, whilst if they are carefully applied they are very durable. They should not, however, be used on smooth, dense surface bricks or bricks which contain a large amount of sulphates because there is always a tendency towards flaking. Then again any failure due to the sulphate content is enhanced when the brick is wet so that as far as possible the paint should be applied in the dry state. In spite of all this it is quite

possible that some flaking will occur at different places due to sulphate action, and in such cases the loose patches should be brushed off and the area rubbed down and allowed to dry before further coats of cement paint are applied.

Bitumen emulsion paints have pigments formulated into an emulsion of high-grade bitumen and water—they have very good water-proofing properties and can be obtained in fairly light colours. However, these colours are often not light enough to give the highest degree of reflection.

Oil water bound paints are not so good from a durability view point as the other types mentioned above for external use, but even so they are often used for decorating old brickwork. However, these tend to flake off and certainly should not be used as a means of water-proofing brickwork.

## Internal Surfaces

When it comes to internal surfaces all the paints mentioned above can be used, and the same problem of flaking can be encountered. However, for interior use, a paint must be easily dried and easily re-decorated, but the water-proofing effect is not very important because it is not good practice to try and prevent damp from coming in by merely painting the inside wall.

When it comes to doing the job of painting attention should be given to the mortar joints which must be sound. Thus any re-pointing which might be necessary should be done before starting to paint, whilst if an oil paint or imitation stone paint is going to be used an alkali-resistant primer should be applied first. Again, external brickwork should be painted in dry weather, and particularly after allowing as much time as possible for the bricks to dry out. When it is seen that brickwork is tending to

## CERAMICS

show efflorescence there is no really certain way of overcoming this defect and if efflorescence is seen on the wall thorough drying is recommended after which the deposit should be brushed off continuously until it ceases. However, if there are faults in the damp course or moisture can enter the wall by other structural defects, drying will not help much and poor painting results can be expected. When it is decided to paint a surface which has previously been painted the type of paint used on the previous occasion should be determined if possible to ensure that the new paint will adhere to the old—thus, for example, an oil paint should not be applied over a bituminous paint, whilst cement paints should only be applied over this type.

Sometimes an old surface has never been painted before and it must be cleaned by washing or using the wire brush. Vegetable matter can be killed by washing with a solution containing copper carbonate 1 oz., 0.880 ammonia 10 oz., water 10 gal., or alternatively 4 oz. per gal. of magnesium silico fluoride. Any dead vegetable growth should be brushed off before beginning to paint.

### Painting Natural Stone

In the case of masonry built from natural stone the reasons for painting may be to prevent the stone from decaying, the repair of shabby surfaces, to restore a previously painted surface or to prevent water penetrating. Here a good oil paint, when it is applied to stone which itself is in good condition and which is dry, has first-rate water-proofing properties. Again, the surface must be dry, and once the outside stone surface has been painted it must be maintained, for when the paint surface is damaged, the stone decays at an even greater rate than before it was protected.

There have been many demands to produce colourless stone preservatives, but there is always a tendency that they may in the end do more harm than good and it is recommended that they should only be used where no great harm will arise if they should prove unsatisfactory.

### Water-proofing

Rain penetration through stone

walls is always a difficulty and a colourless water-proofing material is often the only means available for protection—but if the stone is porous the water-proofing agent must be renewed regularly. When the stone is dense and impermeable, rain often gets through the mortar itself or cracks between the mortar and stone, and it is then necessary to repoint with a 1:1:6 or a 1:2:9 cement lime/sand mortar, after which the water-proofing agent is applied. When, however, the stone is sound a cement paint which both fills and closes the fine cracks is well worth trial. Once again mortar joints must be sound when the painting is undertaken, and again it is necessary to be very careful when it comes to painting stonework where there is a tendency towards efflorescence. Again the deposit should be brushed off and swept up before proceeding—next the surface should be washed with water, dried, and the brushing, washing and drying process carried out until the growth ceases, and, of course, structural repair is essential to prevent water getting into the dried stone surface.

Painted surfaces which are old must be cleaned to remove dirt, and joints must be examined. To use chemical materials as cleaning agents may be unsatisfactory and even dangerous—where there is vegetable growth the cleaning solutions mentioned previously should be used.

Above all it is important in the case of stonework that once painting has been used as a means of protection it is subject to periodical re-painting.

*With acknowledgement to: British Standard Code of Practice, C.P.201: 1952, Painting, Lambeth Boiler House, S.E.3.*

**Electric Construction Co. Ltd.**—Three leaflets have been received from the Electric Construction Co. Ltd., Wolverhampton, dealing with (1) their "Inner-cooled" electroplating rectifiers, (2) a range of manufacture of rotating electrical machines, switch and motor control gear, static transformers, rectifiers and indicating instruments. Under the title, "Industries We Serve," there is an interesting account of some of the typical installations covering the papermaking, public water supply, coalmining, textiles, distillation and heavy rubber industries. Further accounts of other industries will appear at a later date.

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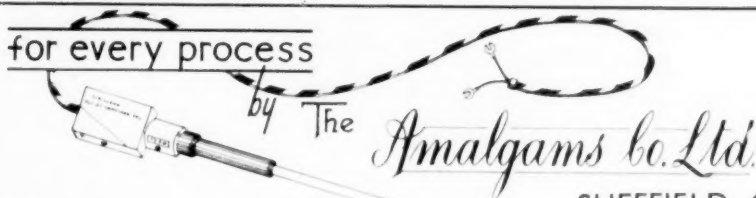
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# Some Applications of Colloid Science in Ceramics\*

by

D. A. HOLDRIDGE, B.Sc., A.R.C.S., D.I.C., F.R.I.C.

(British Ceramic Research Association)

CLAY is the principal agent responsible for the introduction of colloidal material into ceramic bodies. The constitution of the clay is complex and a number of clay minerals have been identified, but in the majority of pottery bodies the mineral with which we are concerned is known as kaolinite, the main component of china clays, ball clays and many fireclays. Of these the proportion of material present in colloidal size varies considerably from clay to clay, but on the average a china clay will contain about 5 per cent. and ball clays roughly 25 per cent. colloidal matter. This can be considered as material of particle size not in excess of 0.2 micron dia. Clearly in pottery bodies, which contain appreciable quantities of milled material, the colloidal fraction is reduced to about a quarter of that present in the raw clays.

## Influence of the Colloid Content on Clay Properties

At first glance it may appear surprising that the relatively low proportion of material of colloid dimensions should exert so profound an influence on the physical properties of ceramic bodies. These particles, however, possess peculiar properties both by virtue of their minute size and also because of their plate-like shape. The most important factor is that the ratio of the area of the surface to the volume of material present has vastly increased. This surface becomes charged electrically by adsorbing negatively-charged ions when in suspension in water, notably hydroxyl

(OH) and, in consequence, is capable of attracting positively-charged ions such as sodium or calcium by virtue of this electrical charge. The adsorbed negative ions and the surrounding attracted positive ions form what is called an electrical "double layer."

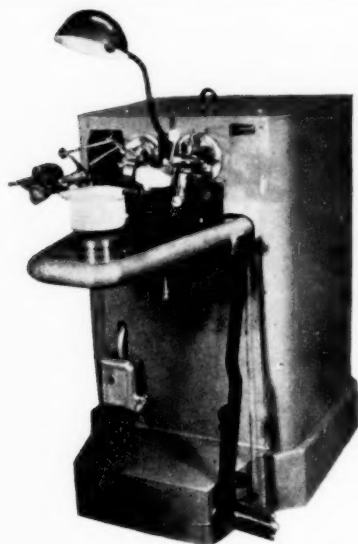
The extent of this double layer depends on the nature of the attracted positive ions and the extent of their hydration. There is evidence that the ions are associated with varying numbers of water molecules, bound to them by electrical attraction, and that the attraction of these ions to the charged colloidal clay particles results in the formation of water films of varying thicknesses. The amount of "free" water, that is, water in which free movement can occur, will consequently vary with the metallic ion associated with the clay and so will affect the flow of the clay slip.

## Responsible for Plasticity

Another effect of the water films associated with the clay colloidal material is that they may be considered to act as lubricants during the working of the ceramic body. The particles can consequently slip over one another when pressure is applied, and provided that the amount of "free" water present is not excessive, the shape imposed on the article during making is retained. In other words, the colloidal matter by virtue of its power to adsorb ions and so to attract water films to its surface, is responsible for the plasticity of the clay and enables articles to be formed by the normal plastic processes.

When we consider the properties of clay slips we are concerned with systems in which the clay content is appreciably lower. The flow properties

\* Reprint of a paper appearing in *Chemistry and Industry*, and *February, 1952*, by courtesy of the Society of Chemical Industries.



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of the slips depend not only on the concentration of clay present, but also on the metallic ions present in the water since these influence the extent of the "bound" water films and, in consequence, the amount of "free" water.

It has been found, for example, that the addition of alkali results in a complex series of changes. Initially the aggregates tend to be dispersed with the result that the volume of the suspended material is reduced, more water is "freed" and the viscosity is lowered, but there is an opposing action in which the attraction of alkali ions to the clay surface, with their attendant water molecules, results in decreased "free" water and an increased viscosity. This occurs at low alkali additions; further additions result in a discharge of some of the negative charges on the colloid so that less water is retained and the slip becomes more fluid. An excessive alkali addition, however, results in partial flocculation, the entrapping of "free" water, and a second decrease in viscosity.

When we are concerned with metal-

lic ions such as calcium and magnesium, which may be present as soluble salts, we find that these steadily reduce viscosity and cause progressive flocculation, an action running counter to that of alkali in the practical working region for casting slips.

### **Practical Significance of Clay Colloids**

Attention has already been drawn to the action of alkalis and of other metallic ions on the properties of clay slips. Clearly this behaviour is of paramount importance in the use of alkaline slips for casting and the casting process.

The significant region for casting lies between the two positions of maximum viscosity attained by alkali addition, but not necessarily at the minimum viscosity position, since there casting may become too slow. The presence of soluble salts can not only flocculate the casting slip but can also result in a scum formation which, on firing, results in a vitreous skin which will not take up glaze readily. Excessive addition of barium carbonate to correct this fault may result in the same effect.



With ceramic bodies the reaction to alkali additions is quicker than with clays on account of the lower colloid content. Small amounts of colloid result in quick response but poor tolerance to excess deflocculants, and benefit can be derived from the addition of colloidal material such as suitable tannins, or silicic acid in the case of bone china bodies. These improve the body tolerance to electrolyte action by protecting the water-repellent body constituents.

Colloids are of significance in cer-

tain other directions also, but space only allows attention to be drawn to the marked effect of altering the metallic ion, associated with a clay, on such properties as strength, plasticity and so forth, and to the fact that benefit has been derived in certain cases by suitable pre-treatment of clays unsuitable in their natural state.

The author wishes to thank Dr. A. T. Green, O.B.E., Director of Research of the British Ceramic Research Association, for permission to prepare both the original paper and this résumé.

## POTTERY PROGRESS AT J. & G. MEAKIN LTD.

THE Eastwood pottery of J. and G. Meakin Ltd., Hanley, is one of a number of potteries which has recently been modernised.

One of the important developments is in the flat ware shop where the drying operations now take place in a chamber which is adjoining, but nevertheless outside, the potter's shop itself. The separation of drying and making processes has improved the atmosphere, causing less heating, humidity, and dust. A patent sloping conveyor scheme minimises the effort required in placing the ware for the drying process, obviating the need of operatives to bend or stretch or, indeed, to move from their actual making positions.

According to an *Evening Sentinel* reporter, who recently had an opportunity of comparing the old way with the new, in a shop where ordinary stove drying was employed, the atmosphere was quite humid, causing spectacles to steam up momentarily and causing a temperature to be registered of 83° F. The close proximity of the drying operations caused a deposition of white dust.

In the new shop the temperature was down to 70° F.

An outstanding feature is a conveyor which moves slowly, serving operatives and the drying chamber, whilst from the conveyor there are suspended more than 300 carriers each with thirteen trays or shelves,

one above the other, thus making one each for the thirteen operatives of the thirteen automatic making machines spaced throughout the shop.

The conveyor slope makes it possible for each operative to receive by carrier his or her own particular tray complete with moulds and at a convenient bench level, immediately to the side of the automatic making machine. The operatives at the lower end of the conveyor use the top tray of each carrier and as the conveyor climbs so the lower trays are raised to a convenient position for the other operators concerned with the making line—the last operative where the conveyor is at its highest point prior to entering the drying chamber, uses the bottom of the carrier. According to the size of the mould, the tray holds two or three and in the time taken for an operative to take the moulds, make the plates, and return them, the next tray with new moulds is ready for continuous operation. The conveyor carriers cover the 100 ft. of drying chamber in about 1½ hours compared with the stove-drying process which usually takes the whole day.

One of the directors of the firm, Mr. Rodney Meakin, apart from commenting upon the increased efficiency of the layout, stresses that the most important point in this new development was the improvement in factory conditions which directly contributed to improved health for the operatives.



# Fused Stabilised Zirconia

## A Modern High-Temperature Refractory

By N. CLARKE JONES, A.M.C.T., M.I.Chem.E., M.Inst.F.

THE present trend in industrial processing and research is towards the use of higher temperatures in order to attain increased efficiency, greater yields, or new and better products. This tendency has created a constantly increasing demand for special refractories which will withstand the higher temperatures employed and which will save fuel and enable it to be used to the best possible advantage. Considerable advances have been made in lightweight and hot-face refractories by utilising bricks and shapes in the A.S.T.M. 2,000° F. class, made either of vermiculite/eyrite or perlite, and recently, in the general refractory field,

for refractory manufacture because of mechanical failure due to inversion, at about 1,000° C. (1,832° F.), of its natural monoclinic crystal structure to tetragonal, with a substantial decrease in volume—a transformation which is reversible. In 1929 it was found that zirconia could be stabilised irreversibly in cubic form at 1,700° C. by means of small amounts of magnesium, calcium, or yttrium oxides, which minimised the change in volume.

Typical analyses of three raw ores containing zirconia are given in Table 1.

Zircon sand ( $ZrSiO_4$ ) is found as a natural mineral in the beach sands of

TABLE 1

|                              | <i>Zircite sand</i> | <i>Zirkite</i> | <i>Baddeleyite</i> |
|------------------------------|---------------------|----------------|--------------------|
| ZrO <sub>2</sub> , per cent. | 65 to 67            | 70 to 79       | 81.6               |
| SiO <sub>2</sub> , per cent. | 30 to 34            | 12 to 18       | 6.3                |
| FeO <sub>2</sub> , per cent. | 0.1                 | 3.6            | 5.0                |
| TiO <sub>2</sub> , per cent. | 0.1                 | 1.2            | 1.0                |

by the introduction of an important new product, fused stabilised zirconia, which has been developed by an American company as a result of research started in 1944. Fused stabilised zirconia was first manufactured in 1946 and cost about 14s. per lb., a price far too high for commercial marketing, but after further research a process was found for producing it in grain form direct from ores at a consumer cost of about 3s. 6d. (\$0.5) per lb., and commercial exploitation followed immediately.

The element zirconium was discovered in 1789 by Klaproth and the exceptional value of zirconium oxide (zirconia) has been recognised for a long time, but it had not been used

Australia and Florida, and, being readily available at reasonable prices, is the raw material chiefly employed for the manufacture of fused stabilised zirconia. Baddeleyite is mainly found in Brazil and is more expensive than zircon sand.

### Manufacture

The patented process employed for the manufacture of the stabilised zirconia includes purification, fusion, and control of crystal-volume stability and the composition of the bodies with regard to grain size. The process reduces the silica content from 33 per cent. to 0.5 per cent. or less. An electric-arc furnace of the Higgins type, comprising iron shells cooled all over with a cascade of water, is employed. The furnace mixture consists of (i)

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## CERAMICS

zirconium ore, (iii) iron borings for metal phase control, added in quantity sufficient to form magnetic ferro-silicon in reaction with the reduced silica, (iii) metallurgical coke as reducing agent, to the extent of two-thirds of the theoretical quantity required to reduce the silica completely, plus 100 per cent. of the theoretical quantity required to reduce all other oxides, plus 20 per cent. excess, and (iv) 3 to 6 per cent. of lime as crystal-stabilising agent. The mixture is fused for about 40 hours, the mass cooled as a solid pig, crushed and sorted out into crude (well-fused) product, refuse (partially fused), ferro-silicon and unfused product. The crude product is finely crushed, mag-

many forms for specific purposes.

The fused stabilised zirconia, with or without 20 per cent. of unstabilised material, is wetted with a suitable organic liquid, e.g., dextrin, and placed in a mould to which is applied a pressure of at least 2,000 lb. sq. in. but preferably 6,000 lb. sq. in. The zirconia is then removed, dried, and sintered in suitable kilns at temperatures of Cone 35 (1,770° C.) to Cone 42 (2,000° C.).

### Properties

Fused stabilised zirconia is principally cubic, with little inversion during temperature-rise. Its general properties are given below, together with some comparative figures for

#### Melting point

|                           |   |
|---------------------------|---|
| Fused stabilised zirconia | 2,550° to 2,600° C. (4,620° to 4,710° F.) |
| Alumina                   | 2,050° C. (3,720° F.)                     |
| Beryllia (Bromellite)     | 2,530° C. (4,580° F.)                     |
| Thoria                    | 3,050° C. (5,520° F.)                     |
| Yttria                    | 2,410° C. (4,370° F.)                     |

#### Density, g./cm.<sup>3</sup> (fused stabilised zirconia)

|                           |          |
|---------------------------|----------|
| True sp. gr.              | 5.6      |
| Bulk sp. gr. (dense)      | 4 to 4.4 |
| Bulk sp. gr. (insulating) | 2.5      |

netically separated and finally calcined under oxidising conditions for several hours at 1,400 to 1,450° C., in order to remove traces of residual carbon. The product has the following average percentage composition: ZrO<sub>2</sub>, 94 to 95; CaO, 4 to 5; SiO<sub>2</sub>, 0.14 to 0.75; FeO, 0.2 to 0.70; TiO<sub>2</sub>, 0.22 to 1.0. It is converted into refractory shapes in two forms, as follows: (1) insulating structure, with 50 per cent. or higher porosity, and (2) dense structure. The latter is produced in all standard brick shapes and in the form of tubes, disks, plates, rods, and in

other refractory materials. Thermal-conductivity figures are given in Table 2.

Although a poor conductor of electricity at low temperatures fused stabilised zirconia is an excellent conductor when subjected to high temperatures, as shown by the resistivity figures given in Table 3.

In regard to load-bearing capacity, when the material is heated at a rate of 10° C./min., collapse occurs with a load of 10 lb. sq. in. at 2,110° C. (3,830° F.) and with a load of 40 lb./sq. in. at 1,950° C. (3,535° F.)—figures

TABLE 2. THERMAL CONDUCTIVITIES (k) OF REFRACTORY MATERIALS  
B.Th.U./hr./sq. ft./in.<sup>2</sup>/° F.)

|                                      | Porosity<br>per cent. | k at<br>1,200° F. | k at<br>1,600° F. | k at<br>2,000° F. |
|--------------------------------------|-----------------------|-------------------|-------------------|-------------------|
| Dense stabilised zirconia            | 28                    | 5                 | 5.5               | 6                 |
| Insulating stabilised zirconia       | 51                    | 3.75              | 4                 | 4.4               |
| Insulating grain-stabilised zirconia | 68                    | 2.25              | 2.5               | 2.75              |
| Fused magnesia                       | 21                    | 23                | 20                | 18.75             |
| Fused alumina                        | 25                    | 20                | 18                | 17.5              |
| Fireclay                             | 15                    | 10.1              | 10.8              | 11.4              |

TABLE 3. ELECTRICAL RESISTIVITY OF FUSED STABILISED ZIRCONIA

| Temperature |       | Resistivity<br>ohm-cm. |
|-------------|-------|------------------------|
| C.          | F.    |                        |
| 700         | 1,290 | 2,300                  |
| 1,200       | 2,190 | 77                     |
| 1,300       | 2,370 | 9.4                    |
| 1,700       | 3,090 | 1.6                    |
| 2,000       | 3,630 | 0.59                   |
| 2,200       | 3,990 | 0.37                   |

which indicate excellent strength-retention at high temperatures.

The good thermal insulating properties of the material are of great value for furnace operation at high temperature, because heat losses are minimised and the highest temperatures more easily reached. Its low specific heat also assures low heat storage despite high bulk density. The chemical stability and inertness make the material suitable for use in both oxidising and reducing conditions. In moulded shapes it withstands temperatures up to 4,550 °F., a figure much beyond the limit of other commercial refractories, e.g., fireclay, 3,000 °F.; fused alumina, 3,300 °F.; and pure oxide of magnesium, 4,000 °F.

Summarising, the significant properties of fused stabilised zirconia are as follows:

- (1) Highest melting point of all commercial refractories.
- (2) Low volatility at high temperatures.
- (3) Lower thermal conductivity than any other commercial refractory, and excellent heat insulator.
- (4) Good thermal-shock resistance.
- (5) Highly resistant to oxidising or moderately reducing furnace atmospheres without volatilisation.
- (6) Low electricity resistivity at high temperatures.
- (7) Low chemical reactivity, even at high temperatures.

#### Applications

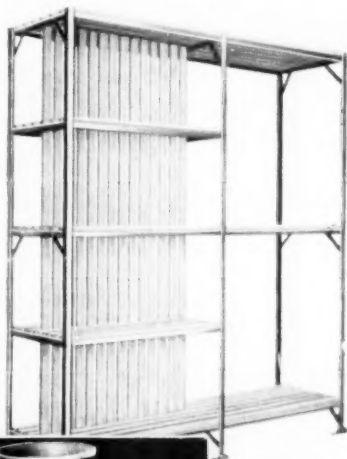
These properties are of such industrial importance and value that immediate use has been found for the material in the metallurgical, electronic and chemical industries. It has been successfully used in contact with molten steel for conveyors and containers, and has been employed in high-frequency induction furnaces for melting platinum at 1,900 °C. (3,450 °F.). In the electronic industry it has

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been found to be the best possible material for kiln setters in the vitrification of barium and strontium titanate dielectrics for capacitors. In the chemical industry, furnaces lined with fused stabilised zirconia refractories have been operated for long periods at temperatures approaching 2,550° C. in gas-synthesis processes and in a neutral or slightly reducing atmosphere. After exposure to high velocity gas stream and to thermal shock the refractories have remained strong. Established uses of fused stabilised zirconia refractories include:

- (1) Furnace linings in ceramic kilns at temperatures above 1,700° C. (3,072° F.), metal melting furnaces (for steel, platinum, refractory alloys, etc.) and gas-synthesis furnaces.
- (2) Thermal insulation in high-frequency induction or resistor-wound furnaces (2,000° C.), using a resistance coil of pure molybdenum wound round a tube of zirconia, with temperature control by automatic current regulation.
- (3) In nitrogen-fixation plant at

temperatures up to 2,315° C. (4,200° F.).

- (4) Electric-furnace heating elements.
- (5) For kiln furniture in the manufacture of capacitors for the communications industry. (The titanate parts are fired to vitrification at about 1,350° C. (2,400° F.), at which temperature they are reactive and adhere to all known refractories except zirconia, beryllia, and thoria, the first-named material being most extensively used.)
- (6) Liners for jet- and rocket-motor tubes, and in gas turbines.

The field of ultra-high temperatures is new and it is therefore expected that uses and processes will be developed through practical experience and as further research results in the production of even purer zirconia.

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1. Clarke Jones, N. Materials of Construction in the Chemical Industry. Vermiculite (Soc. Chem. Ind., London, 1950).
2. Ballard, A. H., and Marshall, D. W. U.S. Pat. 2,535,526 (1950).

# Glass Valves for Vacuum Control

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ONE of the problems encountered in vacuum practice is the ready and accurate control of gas flow into or through the system. It is important that the device used for such control should not be a source of contamination and should not liberate unwanted gases. The standard stop-cock normally used for this purpose has been found unsatisfactory because its grease seal does not permit application of the high heats necessary for degassing. This results in undesirable contamination while the grease itself is a source of trouble.

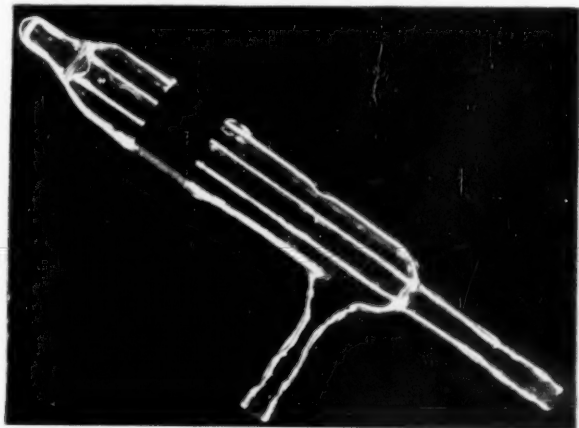
To overcome these and other difficulties, as well as to provide an improved seal, R. Forman of the U.S. National Bureau of Standards electron tube laboratory has developed a glass-seal type of valve which operates at pressures of the order of  $10^{-7}$  mm. of mercury. The new valve depends on the expansion of glass or metal when heated. This elongating characteristic is utilised to break a glass seal which separates the vacuum system from another of higher pressure. When

the source of heat is removed, contraction of the glass reseals the system.

The valve has the appearance of a conventional water condenser with but one side-arm. It is made of 7052 hard glass, chosen because its coefficient of expansion matches that of a Kovar sleeve inserted into the outer jacket. The centre tube is sealed at one end and terminates at the other end in a graded seal, permitting the incorporation of the unit into any pyrex system requiring this type of control.

One of the properties of two specially polished surfaces is the enhancement of the intermolecular force which acts to hold the two surfaces in contact. Before incorporation into the system, the concentric tubes of the glass valve are carefully cut with a glass saw, and the surfaces are optically polished to a high degree of flatness. The ends are then placed in contact once again and are held in this position by the molecular force. A forepump is connected to the inner tube, and the unit is pumped to some

The new glass-seal valve



## CERAMICS

convenient value of vacuum. With the external pressure and the inter-molecular forces holding the cut sections together, the outer jacket is glass-welded with a sharp flame. At this stage, there are two forces on the inner tube; the molecular adhesion and the external air pressure. During the cooling process, contraction adds another force. The total effect of these forces makes the seal vacuum-tight.

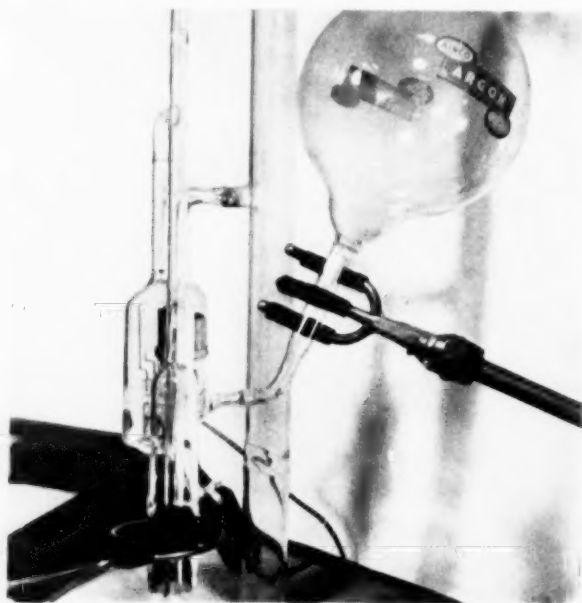
Under standard operating conditions, the inner tube is at the desired vacuum, and the space between the inner and outer tubes is at approximately the same pressure as the gas to be admitted to the system. The Kovar sleeve is heated to a temperature of about 200° C. by an induction heater, and heat flows from the Kovar into adjacent parts of the outer glass jacket. The overall expansion of the outer tube exerts a force which opens the cut in the inner tube. When the desired quantity of gas has entered the system, the induction heater is turned off, and the resulting contraction of the outer jacket once again seals the system.

In operations requiring the admission of special gases to the system, a gas bottle is sealed to the sidearm.

Several variations of this particular design and use of the glass valve are possible. Instead of the Kovar sleeve inserted into the outer jacket, the unit can be made entirely of pyrex, and the heat necessary to cause an expansion supplied by an external heater.

Tests have shown that this valve makes possible a continuously variable control of the rate at which gas can be admitted to an evacuated system. Complete data are not yet available for establishing a lower limit for use as an adjustable leak. However, initial measurements indicate that leakage through the valve into a one litre volume will raise the gas pressure by as little as several tenths of a micron in 1 hour. Another application for this device would be as a calibrated leak for a mass spectrometer leak detector.

**Goodlass, Wall and Lead Industries' Board Changes.**—Mr. J. L. McConnell has relinquished his position as managing director, but will continue as chairman of Goodlass, Wall and Lead Industries Ltd. Mr. R. L. H. Lancaster, Mr. S. Cahn and Mr. R. A. Cookson have been appointed managing directors, Mr. A. P. Low has been appointed a director.



The valve  
(left foreground)  
incorporated  
in the  
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# CRACKING IN VITREOUS ENAMEL

UNDOUBTEDLY this familiar defect is appreciated both by the vitreous enameller and his customer, but there are many cracks which cannot be seen by the eye. Some time ago a study of these small cracks was made by the electrified particle expansion method in which a special form of calcium carbonate was blown through a composition tubing, and in passing rubbed off electrons on to the tube, thus emitting powder which was electrostatically charged positively.

When such positively charged powder makes contact with vitreous enamel on a metal base, the electrons in both the enamel and the base tend to become attracted. However, the metal, being a conductor, allows its electrons to flow in the direction of the positively charged carbonate on the enamel surface. Thus, if the enamel is cracked, the carbonate positively charged particles are attracted to this point and show themselves by a build-up of powder which can be seen.

In vitreous enamelling, if cracks are present, they tend to discolour, and to detect them it is quite common to rub carbon black, or oil, or ink on to the surface, and if no cracks are found by this method it is assumed that none are present. There is, however, always the possibility that those cracks, not detected by this latter method, will open during transport, leading to discolouration.

## Theoretical Considerations

In the *American Ceramic Society Bulletin*, February, 1952, pp. 33-38, there appears a paper by Henry N. Staats of the Magnaflux Corporation, Chicago, Ill., in which he deals with the theoretical considerations in the cracking of vitreous enamel, which concludes with the following summary:

"It would appear, from experimental work and experience gained with

the use of Statiflux\* in the field during the past four years, that the occurrence of cracking in glass and enamels is not a simple subject. Undoubtedly, there are many other factors, not mentioned in this paper, which influence the occurrence and severity of cracking. However, on the basis of this work alone we can surmise that cracks formed in enamels generally occur because of tension stresses on the surface of the enamel and thus weaken it to a future lower tension stress. In addition to this we have found that the same crack formed in tension weakens or sensitises the cracked area to a comparatively mild compression stress which ordinarily might have been ignored had the tension crack not been present.

"One important point to remember is that in many instances it seems necessary that a stress opposite to the original cracking stress must be applied in order to cause failure or removal of enamel. This may explain why shake and impact tests do not always correlate with field failures. In other words, if a packaged enamelled object receives a crack somewhere on the assembly line, the stresses placed on the object during the proof testing may not be in such a direction as to induce failure. In fact, there is a good possibility, ironically enough, that the very act of shaking, or impacting may induce cracks which can increase the likelihood of field failure, particularly when the tested specimen is subjected to compression stresses.

"Summing up, on the basis of the evidence presented in this report, cracks in enamel seem to follow certain general rules. These are:

\* Statiflux, trade name of the Magnaflux Corp., applied to materials and equipment for use with Electrified Particle Inspection Methods. These methods are described by U.S. Letters Patent No. 2,660,666 and other patent applications now pending.



# SAVED!

Leading manufacturers of pencils and crayons have applied the Wet Milling MIKRO-PULVERISER to grinding their clay-graphite and colour sludges. It has been previous practice to ball mill this sludge. In one plant the former procedure had been to run a batch of about 150 gallons in ball mills requiring a total of 25 h.p. for a period of more than 50 hours. The same finished product is produced in a Wet Milling MIKRO-PULVERISER in 8 hrs. using 10 h.p. — 1250 h.p. hrs. compared to 80 h.p. hrs.

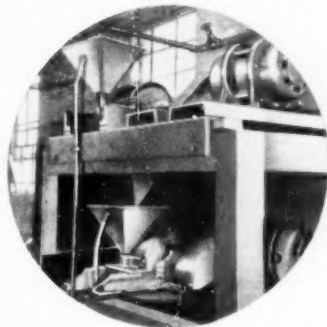
The Wet Milling MIKRO-PULVERISER has found a considerable use in the food products field, colour and dyestuff industry, as well as for pharmaceutical ointments and the chemical, clay, cosmetic and insecticide industries. It is equally successful on both pastes and slurries. For grinding solids in suspension, or subjecting the material to an intensive mixing action—the MIKRO generally will do either, and do it better with less power. Also available for Dry Milling, our full line of MIKRO-PULVERISERS and MIKRO-ATOMISERS noted for thorough blending and precise particle control . . . grinds from granular to ultra-fine in lower micron range . . . capacities from 75 to 25,000 lbs. per hour. For complete recovery of solids and elimination of industrial dusts, investigate our MIKRO-COLLECTOR.

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*Two-pass Wet Milling MIKRO-PULVERISER installation grinding clay-graphite and coloured sludges for a pencil manufacturer*

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**MIKRO-ATOMISER**  
**MIKRO-COLLECTOR**  
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1. Cracks in glass or enamels can exist too small to receive a discolorant or be detected by the human eye.

2. Cracks are detectable down to less than a tenth of a micron in width by the use of Electrified Particle Inspection Methods.

3. Cracks always occur at right angles to the direction of an applied stress.

4. Tension cracks weaken enamels to a secondary, lesser applied tension stress.

5. Tension cracks appear to sensitize enamels to subsequently applied compression stress.

6. The wedging action of included dirt, hydrated crystal growth, or mismatched glass particles in a crack may account for the apparent sensitization of a tension crack to a subsequent compression stress.

"It should be stated that the Electrified Particle Inspection Method is an extremely sensitive engineering and inspection tool which can, and has, played an interesting and valuable role in the field of non-destructive testing

"Like any other non-destructive test, its use must be justified in terms of the need for such a test and value received.

"The only complaint ever levelled at the method has been the fact that it has been too sensitive for the purpose of locating cracks in many ceramic products. A microscope is used to obtain information out of view of the human eye. The electrified particle inspection method also is used to obtain information out of view of the human eye. With either instrument, the observer always reserves the right to reject or accept his findings. It would seem that in the quest for truth a more serious complaint against any such test or instrument would be the fact it was not sensitive enough.

"There is no known non-destructive test method which can solve a problem directly. Methods of this kind are inert things. They cannot think; this must be done by man. Statiflux must be used with the understanding that it is one more tool in the engineer's bag of tricks, not as a revealer of deep, dark sins of the enameller."

# AMERICAN SELLING— An Observation

by

JOHN H. LAWRENCE\*

*Mr. Lawrence has just returned from arranging an American distributor for his company in Cleveland, one having been already appointed in San Francisco. His comment on selling in America is forthright! In Britain we might think we see an immature schoolboyishness in the American approach to business—but when we wish to sell goods there, it is as well to remember that the American customer not only thinks he is right—he is darned sure! Mr. Lawrence is not engaged in the Ceramic industry but his opinion is of interest.—(Editor)*

I HAVE just returned from my trip to the U.S.A. and Canada. It was perhaps the most enlightening of all my visits to the American continent, because I believe I now know what "makes American business tick." American sales methods are different from ours, and before we can appreciate them it is perhaps first necessary to acquaint ourselves with the mentality of the American businessman.

## The American Mind

From early childhood the American is constantly having it driven home that he is an American; the tendency is to grow up in the belief that, by virtue of this, he is on a higher level. From childhood he is steeped in the value of the dollar, and proudly (perhaps justifiably so), the grandeur and importance of American business is essentially moulded in his mind. Consequently he reaches maturity deeply believing that no one could possibly manufacture a better article or produce a finer merchandise than the Americans.

In all probability, when he enters the business sphere such a man will obtain a position with a very large company. He will be but a small link in a vast chain, at a salary commensurate with the standard of living in America.

It is to this man that the efforts of the sales' representatives from Britain must be directed. He will be very

polite, yet at the back of his mind will be: "What can he offer that we do not yet have in the U.S.A.?" He is already prejudiced! However, he is impressed by the British visitors' sincerity and integrity, which lacks all the methods of American high-pressure salesmanship. Quiet sincerity can and does arouse interest; through gentle agitation of this interest, it seems to seep slowly through him that a miracle has happened in the shape of an article either unknown to, or of a higher quality than, that produced in his own country!

It will now become a question of price. Even if he is satisfied on this point, however, he is loath to be the first man to try the product. Consequently and inevitably he will wish to see proof of the success of the product; who uses or buys it, and why?

That he has tried out and satisfied himself of the efficiency of the product influences him less than recorded proof that the product has been proved a great success by others (preferably in his own country).

Testimonials from well-known corporations can therefore be decisive! Having satisfied him on all these points, the British salesman now finds himself confronted with a number of technicians, each an expert in his own particular field.

This is where the Americans score over us ever time. Where we would normally employ one technician in the capacity of a chemist or engineer, they

\* Managing director, Jodelite Ltd.

employ perhaps eight people; but each one is specialised in one aspect only, to a degree that makes him a sectional expert. Thus, the American buyer has to be convinced on distinct issues; namely, superiority of your product; its previous success in reputable concerns; price; its functional and theoretical efficiency proved in expert terms and, finally, guaranteed punctual delivery. When all technicians have been satisfied, the question of delivery arises!

I have found that only a few firms will "go for a proposition" in a small way. Most are either not interested or else "go for it in a big way." If the product is not manufactured locally so that regular deliveries cannot be guaranteed, all selling effort has been wasted. Once the sale has been made, it is of vital importance that regular service calls are made, and that due consideration is given—even socially—to the man or men primarily interested.

#### Advertising

Whatever the product sold, it must be well advertised. To the American business mind, a product that is not advertised does not exist. Again, Americans are educated to take in publicity, and are susceptible to the influence exercised by publicity. They apparently do not tire of advertisements being screamed at them, shown on TV films, posters, magazines and novelties. They love advertising stunts.

Our form of conservative publicity does not appeal to them as American publicity does not appeal to us. They maintain that if a product is good, then why not shout about it?

Due to the very high cost of living, the rearmament programme and the inflationary tendency prevailing in the U.S.A., costs of products or processes are now not always the first consideration, providing that the merchandise offered is not out of all proportion to the American equivalent—if indeed there is one.

I have found that to a large corporation it means little to dismiss as redundant a perfectly new installation of machinery if a better one is found. By this method they maintain their incredible high level of efficiency and labour saving. For quality they still look upon us or Switzerland as the

criterion, but then they say: "Who wants quality, who wants the product to last for ever?"

To summarise, their entire economy and production is based on replacement of fabricated products at as short as possible intervals permitting even the not-so-well-off people to avail themselves of the latest model.

British salesmen must approach them accordingly.

## AIR FILTER

**AIR CONTROL INSTALLATIONS** Ltd., Ruislip, Middlesex, have produced an informative leaflet describing their multi-ray, automatic, self-cleaning, viscous air filter.

The plant operates by a system of closely overlapped panels from attachments on two endless chains which rotate to form a dense, continuous filter in the form of a curtain in the air stream. At the bottom, when the panels turn, they separate, passing through a reservoir containing the filter fluid, whilst the dirt settles as a sludge on the bottom of the reservoir. Normally the sludge is removed when it is about 2-3 in. deep and there is a sludge scraper and sludge pan provided.

Various types of panel are available such as folded and crimped galvanized wire mesh, with the upper part coated with bakelite fibre—(Type MS). Another pattern (MV), is less high and is used where resistance must be kept as low as possible. The type (DD), is die-stamped from sheet metal with louvres at an angle of about 45°. This is recommended where there is a heavy dust concentration and where the atmosphere is liable to contain lint. All panels are interchangeable.

The leaflet provides technical data to help in the selection of the appropriate panel and the number required.

**Colour and Lighting.** It is announced that the exhibition on Colour and Lighting in Industry, postponed from March, will be opened by the Rt. Hon. David Eccles, M.P., Minister of Works, at 12 noon on the 2nd May. The exhibition will show colour ranges and demonstrate the principles affecting the use of colour, and also various types of artificial light and their relation to colour. Enquiries should be made to the British Colour Council, 13 Portman Square, London, W.1.

# The British Iron and Steel Research Association

## Extracts from the Annual Report of the Council—1951

### Blast Furnace Refractories Joint Committee

THE main work of this Committee has been the examination of blown-out furnace linings. This year several carbon hearths have been investigated and it is suggested that infiltration of air or steam from the foundations may produce, in the hearth, oxidation of the edges of carbon blocks, which are then readily loosened and able to float up into the metal.

Results from ferro-manganese furnaces have shown that ferro-manganese metal in the hearth or in impregnated bricks is readily oxidised. When bricks are impregnated with metal, oxidation causes severe distortion of the bricks; this may explain the several recorded instances of ferro-manganese furnaces rising from their foundations.

The catalysis of carbon deposition and the mechanism of the reaction are being systematically examined. The work has shown that high-temperature firing of bricks has two effects which reduce the disintegration of refractory materials caused by carbon deposition. These are the neutralisation of active iron spots by causing the iron to combine with alumina and silica, and the increase in the structure density of the brick; this increased density may help to localise the spread of disintegration to small areas.

Recent work on tap-hole clays was reported at the Nineteenth Blast Furnace Conference; papers were also presented on aspects of tap-hole practice and experiences with various tap-hole guns. The success of the wide range of clay compositions used for stopping tap-holes has stressed the importance of the gun and general mechanical items as important factors in tap-hole practice.

The Refractories Section has continued collaborative work with the British Ceramic Research Association and with steel and refractory manufacturers through the Joint Refractories Committee. Preparations have been made to begin laboratory projects at Battersea; work on some projects has already begun.

### The All-basic Open Hearth Furnace

During the year work has continued on this project of the All-basic Furnace Sub-Committee. Furnaces have been operating

at the works of Steel, Peech and Tozer, the Consett Iron Company, Stewarts and Lloyds Ltd., and Guest Keen Baldwins Iron and Steel Co. Ltd. Most of the details of the trials were given and discussed at a Steelmaking Conference at Ashorne Hill. This conference covered the whole field of all-basic furnace development from its earliest history to the latest available information on the work in this and other countries, including a full report from Holland. The general conclusion was that while some works, particularly that of Stewarts and Lloyds Ltd., were obtaining much increased refractory life and steel output, in general the economics were still uncertain. The shortage of metallurgical raw materials tended at the moment to diminish interest in the all-basic furnace but it was thought vital to continue even more vigorously the work of the Sub-Committee in order to maintain progress. A recent trial at Consett with fired bricks instead of the chemically bonded bricks used earlier, tends to confirm the impression that on a given furnace no marked differences occur among the lives of various brands of roof bricks considered satisfactory from laboratory tests. In the furnace at Guest Keen Baldwins Iron and Steel Co. Ltd., sloping of the ends has not resulted in the advantages obtained at Richard Thomas and Baldwins Ltd., neither does increased output result in diminished fuel consumption as is the case at Steel, Peech and Tozer.

A number of projects for the study and improvement of the refractories suggested by the All-Basic Furnace Sub-Committee have been begun by the Basic Bricks Sub-Committee.

### Open Hearth Refractories Testing

Owing to high cost and certain technical difficulties, the apparatus for testing open hearth roof refractories and studying the effect on them of varying operating conditions has not been constructed. It has been decided to proceed by stages, beginning with a small laboratory furnace, now in course of construction, in which dust-laden gases are made to impinge on a 3-in. diameter brick surface. Gas flow conditions are arranged to minimise impingement of the dust on hot furnace parts.

**Casting Pit and Electric Furnace Refractories**

Work on basic lined ladles has been reported by the United Steel Companies Ltd. and by John Summers and Sons Ltd., from which it is clear that, in spite of the much higher resistance to wear as compared with fireclay, successful results from a variety of basic materials have so far not been achieved. This is because removal of tightly-adhering slag results in serious loss of the refractory. Further research will probably be directed towards producing a basic refractory which will neither build up nor wear away. Reports on trials on electric furnace refractories indicated that in some cases chrome-magnesite-filled steel tubes have lives appreciably longer than those of other refractories tried. Work has continued on the examination of used refractories of various kinds from different parts of electric furnaces.

**Steel Foundry Refractories**

It has been found that electrical resistance strain gauges have defects which render them unsuitable for use in weighing a con-

verter during blowing. It is hoped to employ for the purpose two B.O.A.C. hydrostatic weighing units.

**Laboratory Refractories**

Various types of refractory ware have been made for a number of applications. A paper on super-refractory materials including carbides, nitrides, borides, and sulphides is in the hands of the British Ceramic Society for publication in their jubilee issue.

**Fundamental Research**

Further experimental work has shown that a single crystal of sapphire, in the form of a thin rod, is corroded by molten sodium silicate and lime-alumina-silica slags at a rate which increases as the speed of rotation of the rod is increased. This indicates that the process of corrosion is diffusion-controlled. Static experiments support this conclusion. It is found that, during the first few minutes, the rate of corrosion decreases with time and is thereafter constant. This is consistent with the building up of a diffusion layer until a certain thickness is reached, when convection and density differences come into play.

**SOME CERAMIC PATENTS**

**A Composite Refractory** (U.S.P. 2, 534, 652) by the Ferro Engineering Corporation describes a moist pressed body portion which is used as a mould with a liner made mostly from Zirconium silicate which is either slip-cast or spun into position.

**A Heat, Corrosion and Chemical-resistant Material** (B.P. 655, 182) describes how the grains of refractory material such as silicon carbide which are to be

ultimately bonded and moulded into shape are coated with a suspension of a protective powder such as sillimanite or alundum together with an adhesive like molasses, borax or sodium silicate. The product is dried completely and if necessary it can be fired at a higher temperature than that at which the final shape is fired.

**A Refractory Mould Composition** (U.S.P. 2, 517, 815) describes the treat-

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## CERAMICS

ment of a refractory with a non-aqueous solution of a plasticisable non-thermo-setting hydrocarbon resin as a binder. This may be baked and then burnt off at a casting temperature of 315-425° C.

**A Saggard of Increased Shock Resistance** (U.S.P. 2, 531, 397) by the Champion Spark Plug Co., describes how the strength of a fired refractory as used for example in tunnel kilns with a temperature between the No. 16 and No. 31 cones may be increased by adding to the mix a mineraliser such as sodium aluminate or calcium aluminate.

**A Refractory Liner for High Temperature Furnaces** (U.S.P. 2, 532, 592) is capable of operating up to about 2,200° F. It is made by adding about 5 per cent. of water to saggard or ball clay; Missouri flint clay which has been burnt and crushed; burst and crushed Bolivar flint clay to which is added a mixture of plaster of paris, powdered alum, potassium manganate and salicylic acid.

**A Clay Slip** claimed to be of improved fluidity (U.S.P. 2, 535, 647) consists of a

mixture of gum Arabic, sodium silicate, caustic soda, sodium pyrophosphate, hexametaphosphate or ammonia 0.05 per cent. The mixture is used as a peptising agent being heated so that the temperature rises not more than 10° C. in 10 minutes.

**Glazed tiles** form the subject of B.P. 655, 143 in which metal which has been enamelled has crimped or wavy wires fastened to the back on differently spaced points. During firing the strain causes the wire to elongate which reduces distortion whilst the wires provide a key during the laying of the tiles.

**On enamelling** (U.S.P. 2, 532, 640) describes a method of cleaning metal surfaces to which white enamel is to be subsequently applied. The process consists of heating in a nitrogenous atmosphere for 1 hour at 870° C. and then cooling to room temperature. The enamel is applied in the normal manner by dipping or spraying and then the whole assembly is heated for 2 min. at 815-820° C. in air.

## ELECTRICITY AND THE POTTERY INDUSTRY

**"ELECTRICITY Helps the Potteries."** "Oldest Industry in the World" will be the theme of the joint display of the Electrical Development Association and the Midlands Electricity Board at the British Industries Fair, Castle Bromwich, Birmingham (Stand No. C 408-509).

The display at Castle Bromwich will include a panoramic three-dimensional presentation of pottery production, from the raw material to the finished product, the electrical aspect being stressed. Visitors will also see a selection of ceramic ware in various stages of production.

In addition there will be a series of live demonstrations illustrating electricity being used in pottery manufacture in the form of light, heat and power. The sequences will include conditioning the clay in a motor-driven pug mill; throwing the clay with a motorised potter's wheel; firing in an electrically-heated batch-oven; brushing the bisque ware with a motor-driven brush and dust extractor; glazing in an electrically-heated glost oven; decorating and gilding china ware at a well-lighted bench, and testing with high-voltage equipment ceramics for use as electrical insulators.

Electrically-heated kilns and ovens save valuable factory space, and increased output and quality of product, and are not dependent upon highly-skilled operatives for maintaining the requisite tem-

peratures. These claims will be supported by display data relating to actual installations of the passage type electric oven, a model of which will be shown. Information will also be displayed in relation to the small batch-oven for firing pottery.

Visitors will be attracted to the stand by the vista of a pottery production line, with live features at the four corners: a pug mill and operator; a thrower at work; a pottery decorator; and electrical insulators being tested. There will also be a cut-out reproduction of an electric tunnel-oven in operation.

## THE MELCHETT MEDAL, 1952

**T**HE Council of The Institute of Fuel have awarded the Melchett Medal for 1952 to Professor D. T. A. Townend, D.Sc., Ph.D., D.I.C., Hon. M.Inst.Gas E., F.Inst.F., in recognition of his outstanding contributions to the science of combustion, particularly in the field of higher hydrocarbons. Dr. Townend is the Director-General of the British Coal Utilisation Research Association; he was formerly Livesey Professor of Coal Gas and Fuel Industries in the University of Leeds, and President of The Institute of Fuel, 1948-50.

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## Heat Treatment of Moulded Carbon Products

THE following is an extract from a paper by H. R. Junkison (Head-quarters Division, North Thames Gas Board), presented recently to the Institution of Gas Engineers, London and Southern Section.

Fig. 1 gives a general view of a continuous kiln used for the heat treatment of moulded carbon products. The kiln is loaded with eight bogies, each containing 6 boxes 4 ft. 6 in. by 2 ft. 0 in. by 2 ft. 0 in., into

which carbon plates are interleaved with metal plates to ensure suitable heat penetration. Fifteen bogies are in use, eight in the kiln, four in pre-heating ovens, and three being loaded or unloaded.

The boxes are topped off with coke fines to exclude the air and to permit of the absorption and removal of the volatiles discharged by the heated carbon. The load on each bogey contains just a little under 1 ton of

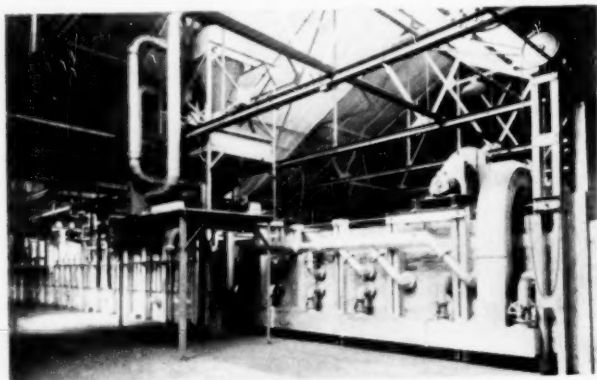
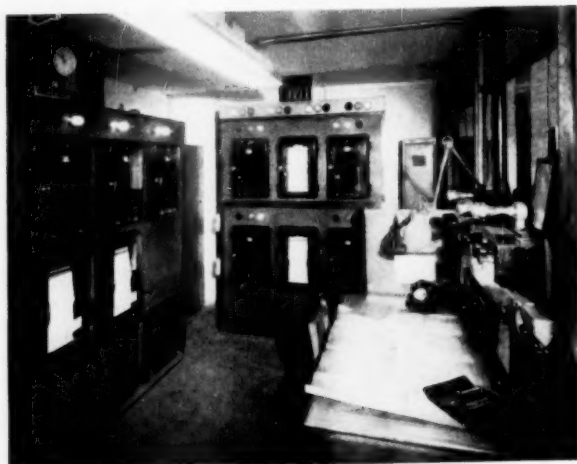


Fig. 1. Tunnel kiln handling large quantities of chemical carbon products

(Courtesy, Powell Duffryn Carbon Products Ltd.)

Fig. 2. Control room showing some of the recorders used in the control of kiln used to give heat treatment of moulded carbon products

(Courtesy, Powell Duffryn Carbon Products Ltd.)



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## KERAMISCHE ZEITSCHRIFT



material. The process time is 80 hours. Production rate is one bogey every 10 hours.

Pre-heating takes place in circulating ovens prior to the material being placed in the kiln, where a very slow rise to 450° C. takes place under exact control to ensure that the early phases of the volatiles absorption is carried out correctly. If improperly heated in this early stage there is danger that the carbon block will be porous. The time spent in these pre-heating ovens is 40 hours. The total process time is therefore 120 hours. The kiln is zoned as follows:

Removal from the pre-heating ovens and the insertion of the load into the kiln means a slight drop to 430° C., at which temperature the first section of the kiln is operated. The succeeding four zones operate at 530°, 680°, 910° and 975° C., each zone being controlled separately automatically.

There are nine temperature recording points throughout the length of the kiln. After the final zone there is controlled cooling for a short period to

200° C. at which temperature the bogies are removed from the kiln and the load allowed to cool.

The kiln produces all standard forms of prepared carbon blocks and tubes suitable for electric goods, such as carbon brushes, low resistance blocks for pick-ups on trolley arms on road and rail transport, and chemical carbon suitable for conveyance of high acid solutions, and tiles for lining acid baths and tanks and for heat exchangers of all types. The kiln uses gas at 3 in. w.g. and air at about 12 in. w.g.

The kiln is controlled throughout by Foster instruments, and Fig. 2 is a view of one end of the control room showing some of the recorders.

The consumption of gas here is now about 9,000 therms a week, which is expected to increase over the next 2 years, as production increases.

**J. F. Coales.** Elliott Brothers (London) Ltd., announce that Mr. J. F. Coales has resigned his position as research director of the Company.

# NEW DEVELOPMENTS

## Conserving Cleaning Materials—Sandblasting —Electronics

**A** RECENT discussion by several U.S. manufacturers of ceramic-coated materials with metallic base, resulted in a number of suggestions in regard to conserving cleaning materials, conserving sulphuric acid and nickel salts, and conserving sodium-cyanide.

Of these, a plant-designed separator tank used in conjunction with the cleaner tank considerably extends the life of cleaning solution. Often these solutions fail to function properly simply because oil scum that has accumulated at the top of the cleaning tank is redeposited on the metal during cleaning. In one plant, a modification of this arrangement is prolonging the life of cleaner tank solutions five times or more when a separate device is used for sludge remover.

Suggestions for saving sulphuric acid are:

(a) When purchasing sulphuric acid, inspect the storage tank, all transfer pipes, and all valves and fittings in order to prevent loss of acid because of failure of these parts;

(b) When measuring acid for addition to the pickling tanks, use a vessel of earthenware or iron to catch dripping acid that might otherwise go to waste;

(c) Nickel salts can be conserved by keeping storage tanks as dry as possible, placing them on pallets off the floor. Several suggestions are also given for preventing waste of nickel salts rendered unfit for use because of the presence of iron sludge in the bath;

(d) Conserving sodium cyanide. At one plant, the use of a relatively small amount of caustic soda has reduced the amount of sodium cyanide required for neutralising solutions by approximately 50%.

(*Better Enamelling*—November, 1951.)

### Red Garnet Sand for Sandblasting

The Ryan Aeronautical Co., San Diego, Cal., consider that actual shop

experience has proved that red garnet sand is a 50 per cent. better sandblasting agent than the ordinary white silica sand. Further, less air pressure is required.

Although it is more expensive, red garnet sand can be used much longer and its action is faster. In an actual shop test through two 8-hour shifts, sandblasting machines using silica sand had to be reloaded six times, whereas only one loading was needed with garnet sand. Experience also showed that the machines were much less likely to clog in damp or rainy weather. The advantages, it is said, have far outweighed the higher initial cost of the raw material.

(*Modern Machine Shop*—December, 1951.)

### Electronics

A recently designed, continuous firing or annealing furnace is so compact that it may enable manufacturers of pottery or glassware to increase productivity by means of automatic controls even in small factories. The furnace occupies only 26 in. x 54 in. of floor space, yet has a firing capacity of about 800 sq. in. per hour. It appears to be well suited to the firing or annealing of small pottery or glass objects in quantities somewhat too large to be handled efficiently by batch type furnaces, but too small for ordinary commercial continuous furnaces. The furnace has been developed for the specific operation of firing pottery or glass plates that have electronic circuit patterns printed on them by a stencil silk-screen process. When used for this purpose, it has more than the combined output of all the seven batch type furnaces previously used in the laboratory. It is a continuous belt machine, using a belt which is woven from a high temperature alloy resistant to corrosion at furnace temperature.

(*Ceramic Industry*—December, 1951.)

# The British Ceramic Society

## Abstracts of Papers

**F**OLLOWING are abstracts of two papers which appear in the Transactions of The British Ceramic Society, Vol. 51, No. 3, March, 1952:

**The Elastic and Viscous Properties of Alumino-Silicate Refractories**, by B. A. Wiechula and A. L. Roberts.—Commercial products covering the whole range of the alumino-silicate series were investigated. Their constitution was studied by means of X-ray analysis, differential thermal analysis and microscopic examination of thin sections. Changes in the mechanical properties at temperatures up to 1,400° C. were examined by torsion methods and values of the modulus of rigidity, ultimate shear strength and the rates of "flow" were determined. Results proved that there was no simple relation between  $Al_2O_3$  content and the values at room temperature for modulus of rigidity or ultimate shear strength. The mineralogical constitution of the bricks, however, could be correlated, at least qualitatively, with these mechanical properties. With rise in temperature the rigidity of the materials increased to a maximum value at about 700° C. In material containing no crystalline silica the rigidity increase was slight, but in the more siliceous materials the increase was substantial and clearly due to the presence of free crystalline silica. Following the development of plasticity (at 700–800° C.) rigidity decreased continuously and rapidly at higher temperatures. Ultimate shear strength tests showed that, in the region in which plasticity was developed and rigidity decreased, the strength of the material was still increasing to a maximum attained at about 900° C. The cumulative evidence of modulus, strength and "creep" tests showed that transition from almost complete rigidity to incipient plasticity occurred between 700 and 800° C., irrespective of the composition of the material. For each material the rate of deformation was related to temperature in a definite manner. This relationship was similar for different materials but comparison of one material with another showed that under the same conditions the rate of "flow" decreased as the alumina content of the material increased, and this appeared to be consistent with the increase in the amount (and probably the size) of mullite and corundum crystals in the structure. The similarity between reciprocal "flow rate" temperature curves for the materials

examined and viscosity curves for quartz glass provided strong additional evidence that the glass present in the materials tested was highly siliceous in character, as would be anticipated from equilibrium data.

The survey is believed to have provided a semi-quantitative correlation between the constitution and mechanical properties of a wide range of alumino-silicate refractories. It confirms that the mechanical properties of these refractories improve as their alumina content increases and affords some indication of the fundamental causes.

**Observations on the Properties of Pottery Fired on Rapid Schedules in some types of Tunnel Ovens**, by W. L. German.—Comparisons have been made of the properties of pottery fired in intermittent ovens and with more rapid schedules. It is concluded that rapid firing in tunnel ovens is unlikely adversely to affect porosity, strength, whiteness and crazing resistance of earthenware. The translucency of bone china fired in a large gas-fired oven was superior to that of the same ware fired in intermittent ovens of the same company.

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**T**HE Sturtevant Engineering Co. Ltd., Southern House, Cannon Street, London, E.C.4, have issued publication No. 9103 entitled "Moritz Grinding Mills," superseding publication No. 9101.

The "Moritz" mill is used to obtain from average to very fine grinding on materials of moderate to extreme hardness. Among the applications may be included the pulverising of minerals and organic products such as barytes, lime, phosphate, gypsum, dolomite, various pigments, colour materials, coal, sulphur, graphite, lithopone, marble, titanium oxide, iron oxide, feldspar, and so on.

Publication No. 8401 which is entitled "Air Flow Conveyors" deals with the suitability of this equipment for the conveyance of many materials such as bauxite, bentonite, carbon dust, cement, cereal, to mention a few, and among the advantages claimed is the small amount of air used and the reduction of the dust problem.

# AMERICAN CERAMIC SOCIETY

**I**n the *Journal of the American Ceramic Society* for March, 1952, the following papers appear, and are abstracted below:

**Fundamental Study of Phosphate Bonding in Refractories: IV, Mortars Bonded with Monoaluminum and Monomagnesium Phosphate**, by William D. Kingery, Division of Ceramics, Department of Metallurgy, Massachusetts Institute of Technology, Cambridge, Massachusetts.

Mortar compositions containing monoaluminum phosphate and monomagnesium phosphate have been investigated. Five compositions developed have been tested for workability, water retention, strength, shrinkage, and appearance in mortar joints at temperatures up to 1500°C. Results obtained indicated that these mortars are equivalent to or superior to commercial mortars for which comparable data are available in the literature. It was found that retardation of phosphate bond migration by ground clay decreased bond strength.

**Significant Aspects of Certain Ternary Compounds and Solids Solutions**, by F. A. Hummel, Division of Ceramics, School of Mineral Industries, The Pennsylvania State College, Pennsylvania.

The discovery of the thermal contraction of  $\beta$ -eucryptite has introduced some new problems regarding the basic assumptions upon which previous thermal expansion theory has been based. These problems are presented together with a discussion of the chemical control of the thermal expansion of  $\beta$ -eucryptite- $\beta$ -spodumene solid solutions. The relationship of the solid solutions to the physical control of the thermal expansion of ceramic mixtures is presented.

**Density Changes in Thermometer Glasses**, by Laurence C. Liberatori and Helen J. Whitcomb, Glass Products Research Department, Taylor Instrument Co., Rochester, New York.

A study was made of the density changes in the thermometer glasses, Corning 0041, 7560, 1720 and an experimental glass, Corning EXP175FK. Thermometers fabricated from these glasses were given similar heat treatments in their respective annealing ranges. Measurements were then made of the ice-point changes at various fixed tempera-

tures from room temperature to the normal upper useful limits of the glasses. Holding periods extended to 1 year. The ice-point change in a thermometer is a measure of the per cent. density change in the gas from which the bulb is fabricated. The relation of this change in density to temperature for a given duration of roasting appears to be well represented by two curves of the form of a constant times a temperature to a power. The value of the power appears to change rather abruptly at some temperature,  $T_0$ , in the neighbourhood of 150°C. below the strain point temperature and to be constant in the regions on either side of  $T_0$ . At equal temperatures below the strain point the behaviour of the glasses is quite similar.

**On the Role of Nickel in Porcelain Enamelling**, by J. H. Keeler, P. K. Chu, and H. M. Davis, School of Mineral Industries, The Pennsylvania State College, Pennsylvania.

Nickel applied to a sheet steel as a nickel flash endures in the surface through several de-enamellings and re-enamellings. The attendant improvement in the enamelling behaviour of the steel is similarly persistent. Heat-treating experiments with and without nickel lead to the conclusion that, while the fired ensemble is cooling, nickel oxide at the interface is reduced by hydrogen issuing from the steel, forming water which enters the enamel and diminishing the hydrogen available for defect production. In this function, a cobalt layer is comparatively ineffective.

**Apparatus for Differential Thermal Analysis Under Controlled Partial Pressures of H<sub>2</sub>O, CO<sub>2</sub>, or Other Gases**, by Robert L. Stone, Engineering Experiment Station, The Ohio State University, Columbus, Ohio.

An apparatus was designed so that an atmosphere (a continuously flowing atmosphere) containing any partial pressure of the active vapour such as H<sub>2</sub>O, CO<sub>2</sub>, or SO<sub>2</sub>, could be maintained around the particles of a mineral powder while the differential thermal analysis was being run. The sample holder and its attendant parts were mounted on a movable vertical shaft so that the assembly could be lowered into or raised out of

the furnace. The gas was carried to the powders under very slight pressure through  $\frac{1}{8}$ -in. dia. porcelain tubes, called the injector, which fit snugly into the sample holder cavities. The bottoms of the cavities were the ends of two 4-hole porcelain tubes which carry the thermocouples and also support the sample holder. Two types of sample holders were used (1) Inconel tubes,  $\frac{3}{8}$  in. in outside dia. and  $\frac{1}{2}$  in. long with a wall thickness of 0.008 in., and (2) a solid Inconel block  $\frac{1}{2}$  in. in dia. and  $\frac{1}{2}$  in. long with two symmetrically placed holes 0.234 in. in dia. drilled parallel to the length. These sample holders accommodate about 0.15 gm. of clay or 0.20 gm. of alumina as the reference material.

There were four 28-gauge thermocouple wires in each cavity. In the sample cell, two wires were one leg of the differential couple and the other two wires were dummies to balance the cell. In the reference cavity were the other leg of the differential couple and the measuring couple. All four wires in each cell were fused into a single bead and the wires were spread as far apart as possible, forming a sturdy unit. The furnace was  $4\frac{1}{2}$  in. sq. and 5 in. long with an Alundum tube core,  $1\frac{1}{2}$  in. in outside dia., on which 45 ohms. of 28-gauge Nichrome V wire was noninductively wound.

A motor-driven Powerstat was used to control the temperature rate at  $16^{\circ}\text{C}$ . per minute.

## CERAMIC PROGRESS

RECENTLY Mr. A. Dinsdale of the British Ceramic Research Association addressed the London Section of the Society of Chemical Industry, offering a paper entitled "Recent Progress in Ceramics." Mr. Dinsdale limited his remarks mainly to the pottery industry. He mentioned the three main groups of clay minerals, confining attention to the kaolinite group. He said that felspathic rocks by the action of carbon dioxide in surface water arising from the earth's crust was decomposed and as a result the clay which was formed might be near the original rock as in the case of china clay, or it might form as a sediment some distance away as happened in the case of ball clay.

He drew attention to the importance of thermal analysis which was a relatively new method which could be used to identify unknown clay substances. Although the optical microscope was of little use for materials such as ball clay in which 90 per cent. was less than 0.3 micron, nevertheless the electron microscope helped to show up differences in clay structure.

He referred to the emergence of the new continuous tunnel kilns to replace the old-fashioned intermittent kilns; the great advantage of the former being reduced labour charges, continuous operation, greater control and more efficient use of fuel. The impact of the tunnel kiln had been felt largely during the post-war period when their number had increased from 90 in 1938 to round about 260 in 1952.

In the discussion which followed Dr. Cameron asked if chamber kilns were

still in use and the speaker stated that a few had been used during the past 30 or 40 years but they were inefficient by comparison with tunnel kilns.

In reply to another questioner Mr. Dinsdale said that open flame fuel oil kilns tended to give a sulphurous atmosphere which would have a deleterious effect upon some products.

Mr. E. W. Jackson referred to the efforts made to get uniformity of oven temperature in tunnel ovens, and he asked whether or not certain decorative finishes needed very different temperatures, and that the ware was placed in the old type of kiln to take advantage of this temperature distribution. He also said that there were no figures given in the comparison of the two types of kiln in relation to waste and rejects, and he wondered whether these figures would show the tunnel oven up in a favourable light. Mr. Dinsdale said the temperature variation still existed even with tunnel ovens and it was used in firing some enamels. However, without giving specific figures he did insist that in terms of waste and rejects the tunnel oven was a great improvement. Mr. J. F. Ronca interjected here to point out that this waste was vitally important, representing as it did 100 per cent. profit.

A question was asked whether luminous flames with their greater radiant heat output might not give more uniform heating, but Mr. Dinsdale said that because ware to be fired was always packed closely together it was necessary to use convected as well as radiated heat to reach the centre of the setting.

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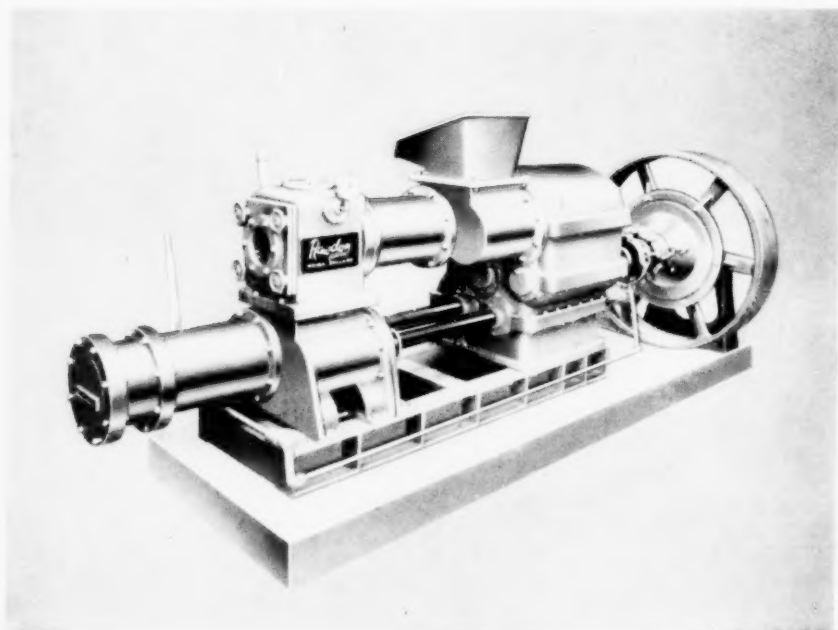
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